Prepared for
Commander, U.S. Pacific Fleet, Executive Agent

In accordance with
The National Environmental Policy Act and
Executive Order 12114

MARIANA ISLANDS RANGE COMPLEX

ENVIRONMENTAL IMPACT STATEMENT/

OVERSEAS ENVIRONMENTAL IMPACT STATEMENT

Volume 2 of 2

January 2009

Draft

Please contact the following person with comments and questions:

Mariana Islands Range Complex EIS/OEIS
Nora Macariola-See, Project Manager, Code EV21
Naval Facilities Engineering Command, Pacific
258 Makalapa Drive, Suite 100
Pearl Harbor, HI 96869-3134
Phone: 808-472-1402
E-mail: marianas.tap.eis@navy.mil

This page intentionally left blank.

TABLE OF CONTENTS

APPENDICES

LIST OF FIGURES

CHAPTER 1 PURPOSE AND NEED FOR PROPOSED ACTION

CHAPTER 2 DESCRIPTION OF PROPOSED ACTION AND ALTERNATIVES

CHAPTER 3 AFFECTED ENVIRONMENT AND ENVIRONMENTAL CONSEQUENCES

3.1 GEOLOGY, SOILS, AND BATHYMETRY

3.2 HAZARDOUS MATERIALS AND WASTES

There are no figures in this section.

3.3 WATER QUALITY

3.4 AIR QUALITY

3.5 AIRBORNE NOISE

3.6 MARINE COMMUNITIES

3.7 MARINE MAMMALS

3.8 SEA TURTLES

There are no figures in this section.

3.9 FISH AND ESSENTIAL FISH HABITAT

3.10 SEABIRDS AND SHORE BIRDS

3.11 TERRESTRIAL SPECIES AND HABITATS

3.12 LAND USE

3.13 CULTURAL RESOURCES

3.14 TRANSPORTATION

3.15 DEMOGRAPHICS

There are no figures in this section.

3.16 REGIONAL ECONOMY

There are no figures in this section.

3.17 RECREATION

3.18 ENVIRONMENTAL JUSTICE AND PROTECTION OF CHILDREN

There are no figures in this section.

3.19 PUBLIC HEALTH AND SAFETY

There are no figures in this section.

CHAPTER 4 OTHER CONSIDERATIONS

There are no figures in this chapter.

CHAPTER 5 MITIGATION MEASURES

There are no figures in this chapter.

CHAPTER 6 CUMULATIVE IMPACTS

LIST OF TABLES

CHAPTER 1 PURPOSE AND NEED FOR PROPOSED ACTION

CHAPTER 2 DESCRIPTION OF PROPOSED ACTION AND ALTERNATIVES

CHAPTER 3 AFFECTED ENVIRONMENT AND ENVIRONMENTAL CONSEQUENCES

3.1 GEOLOGY AND SOILS

3.2 HAZARDOUS MATERIALS AND WASTE

3.3 WATER QUALITY

3.4 AIR QUALITY

3.5 AIRBORNE NOISE

3.6 MARINE COMMUNITIES

3.7 MARINE MAMMALS

3.8 SEA TURTLES

3.9 FISH AND ESSENTIAL FISH HABITAT

3.10 SEABIRDS AND SHORE BIRDS

3.11 TERRESTRIAL SPECIES AND HABITATS

3.12 LAND USE

There are no tables in this section.

3.13 CULTURAL RESOURCES

3.14 TRANSPORTATION

3.15 DEMOGRAPHICS

3.16 REGIONAL ECONOMY

3.17 RECREATION

3.18 ENVIRONMENTAL JUSTICE AND PROTECTION OF CHILDREN

3.19 PUBLIC HEALTH AND SAFETY

CHAPTER 4 OTHER CONSIDERATIONS

CHAPTER 5 MITIGATION MEASURES

CHAPTER 6 CUMULATIVE IMPACTS

Acronyms and Abbreviations

µg/L	micrograms per liter
µm	micrometers
µg/m^3	micrograms per cubic meter
µPa^2-s	squared micropascal-second
µPa	micropascal
A-	Alert Area
A-A	Air-to-Air
A-G	Air-to-Ground
A-S	Air-to-Surface
AFB	Air Force Base
AAFB	Andersen Air Force Base
AAMEX	Air-to-Air Missile Exercise
AAV	Amphibious Assault Vehicle
AAW	Anti-Air Warfare
ABR	Auditory Brainstem Response
ACHP	Advisory Council on Historic Preservation
ACM	Air Combat Maneuvers
ADAR	Air Deployed Active Receiver
ADC	Acoustic Device Countermeasure
ADV	SEAL Delivery Vehicle
AEER	Advanced Extended Echo Ranging
AEP	Auditory Evoked Potentials
AESA	Airborne Electronically Scanned Array
AFAST	Atlantic Fleet Active Sonar Training
AFB	Air Force Base
AFCEE	Air Force Center for Environmental Excellence
AFI	Air Force Instruction
AGE	Aerospace Ground Equipment
AGL	Above Ground Level
AICUZ	Air Installations Compatible Use Zones
AIM	Air Intercept Missile
AK	Alaska
AMRAAM	Advanced Medium-Range Air-to-Air Missile
AMSP	Advanced Multi-Static Processing Program
AMW	Amphibious Warfare
ANNUALEX	Annual Exercise
AOR	area of responsibility
APCD	Air Pollution Control District
APZ	Accident Potential Zones
AQCR	Air Quality Control Region
AR	Army Reserves
AR-Marianas	Army Reserves Marianas
Army	U.S. Army
ARPA	Archaeological Resources Protection Act
ARS	Advance Ranging Source
ARTCC	Air Route Traffic Control Center
AS	Assault Support
ASDS	Advanced SEAL Delivery System
ASL	Above Sea Level
ASTA	Andersen South Training Area
ASTM	American Society for Testing and Materials
ASUW	Anti-Surface Warfare
ASW	Anti-Submarine Warfare
AT	Anti-Terrorism
AT/FP	Anti-Terrorism/Force Protection
ATC	Air Traffic Control
ATCAA	Air Traffic Control Assigned Airspace
atm	atmosphere (pressure)
ATOC	Acoustic Thermometry of Ocean Climate
ATSDR	Agency for Toxic Substances and Disease Registry
AUPM	Above & Underground Storage Tanks and Pesticide Management
AUTEC	Atlantic Undersea Test and Evaluation Center
AV-8B	Vertical/Short Takeoff and Landing Strike Aircraft
AW	Air Warfare
B-1	Strategic Bomber
B-2	Stealth Bomber
B-52	Strategic Bomber
BA	Biological Assessment
BAMS	Broad Area Maritime Surveillance
BASH	Bird Aircraft Strike Hazard
BDA	Battle-Damage Assessment
BDU	Bomb Dummy Unit
BMDTF	Ballistic Missile Defense Task Force
BMP	Best Management Practices
BO	Biological Opinion
BOMBEX	Bombing Exercise
BQM	Aerial Target Drone Designation
BRAC	Base Realignment and Closure
BSP	Bureau of Statistics and Plans
BSS	Beaufort Sea State
BZO	Battle Sight Zero
°C	degrees Centigrade
C2	Command and Control
C-4	Composition 4
C-130	Military Transport Aircraft
CA	California
CAA	Clean Air Act
CAL	Confined Area Landing
CAN	Center for Naval Analysis
CAS	Close Air Support
CASS	Comprehensive Acoustic System Simulation
CASS-GRAB	Comprehensive Acoustic System Simulation Gaussian Ray Bundle
CATM	Combat Arms and Training Maintenance
cc	cubic centimeter(s)
CCD	Carbonate Compensation Depth
CCF	Combined Control Facility
CDS	Container Delivery System
CEQ	Council on Environmental Quality
CERCLA	Comprehensive Environmental Response, Compensation and Liability Act
CFR	Code of Federal Regulations
CG	Cruiser
CHAFFEX/FLAREX	Chaff/Flare Exercise
CHESS	Chase Encirclement Stress Studies
CI	Confidence Interval
CIP	Capital Improvements Program
CITES	Convention on International Trade In Endangered Species
CIWS	Close-in Weapons System
cm	centimeters
CMC	Northern Mariana Islands Commonwealth Code
CMP	Coastal Management Plan
CNEL	Community Noise Equivalent Level
CNO	Chief of Naval Operations

CNRM	Commander, Navy Region Marianas
CNMI	Commonwealth of the Northern Mariana Islands
CO	Carbon Monoxide
CO_2	Carbon Dioxide
COMNAVREG	Commander, Navy Region Marianas
COMNAVMAR	Commander, United States Naval Forces Marianas
COMPACFLT	Commander, Pacific Fleet
COMPTUEX	Composite Training Unit Exercise
COMSUBPAC	Commander, Submarine Forces Pacific
CONEX	Container Express (Shipping Container)
CONUS	Continental United States
CPF	Commander, U.S. Pacific Fleet
CPRW	Commander, Patrol and Reconnaissance Wing
CPX	Command Post Exercise
CQC	Close Quarters Combat
CR	Control Regulation
CRE FMP	Coral Reef Ecosystem Fishery Management Plan
CRG	Contingency Response Group
CRM	Coastal Resources Management
CRRC	Combat Rubber Raiding Craft
CRU	Cruiser
CSAR	Combat Search and Rescue
CSG	Carrier Strike Group
CSS	Commander, Submarine Squadron
CT	Computerized Tomography
CTF	Cable Termination Facility
CUC	Commonwealth Utilities Corporation
CV	Coefficients of Variation
CVN	Aircraft Carrier, Nuclear
CW	Continuous Wave
CWA	Clean Water Act
CY	Calendar Year
CZ	Clear Zones
CZMA	Coastal Zone Management Act
DARPA	Defense Advanced Research Programs Agency
DAWR	Division of Aquatic and Wildlife Resources
dB	Decibel
dBA	A-Weighted Sound Level
DBDBV	Digital Bathymetry Data Base Variable
DDG	Guided Missile Destroyer
DDT	Dichlorodiphenyltrichloroethane
DES	Destroyer
DESRON	Destroyer Squadron
DEQ	Department of Environmental Quality
DFW	CNMI Division of Fish and Wildlife
DICASS	Directional Command Activated Sonobuoy System
DLCD	Department of Land Conservation and Development
DNL	Day-Night Average A-Weighted Sound Level
DNT	Dinitrotoluene
DoD	Department of Defense
DoD REP	DoD Representative Guam, Commonwealth of Northern Mariana Islands, Federated States of Micronesia and Republic of Palau
DoN	Department of Navy
DPW	Department of Public Works
DTR	Demolition Training Range
DZ	Drop Zone
EA-6	Electronic Attack Aircraft
EA-18	Electronic Warfare Aircraft
EA	Electronic Attack
EA	Environmental Assessment
EAC	Early Action Compact
EC	Electronic Combat
EC OPS	Chaff and Electronic Combat
ECSWTR	East Coast Shallow-Water Training Range
EER	Extended Echo Ranging
EEZ	Exclusive Economic Zone
EFD	Energy Flux Density
EFH	Essential Fish Habitat
EFSEC	Energy Facility Site Evaluation Council
EGTTR	Eglin Gulf Test and Training Range
EIS	Environmental Impact Statement
EL	Sound Energy Flux Density Level
EMATT	Expendable Mobile ASW Training Target
EMR	Electromagnetic Radiation
EMUA	Exclusive Military Use Area
ENP	Eastern North Pacific
ENSO	El Niño/Southern Oscillation
EO	Executive Order
EOD	Explosive Ordnance Disposal
EODMU	Explosive Ordnance Disposal Mobile Unit
EPA	Environmental Protection Agency
EPAct	Energy Policy Act
EPCRA	Emergency Planning and Community Right to Know Act
ER	Extended Range
ES	Electronic Support
ESA	Endangered Species Act
ESG	Expeditionary Strike Group
ESGEX	Expeditionary Strike Group Exercise
ESQD	Explosive Safety Quantity Distance
ET	Electronically Timed
ETP	Eastern Tropical Pacific
EW	Electronic Warfare
EX	Exercise
EXTORP	Exercise Torpedo
°F	degrees Fahrenheit
FA-18	Flight/Attack Strike Fighter
FAA	Federal Aviation Administration
FAC	Forward Air Control
FACSFAC	Fleet Area Control and Surveillance Facility
FAD	Fish Aggregating Devices
FAST	Floating At-Sea Target
FAST	Fleet Anti-Terrorism Security Team
FCLP	Field Carrier Landing Practice
FDM	Farallon de Medinilla
FDNF	Forward Deployed Naval Forces
FEA	Final Environmental Assessment
FEIS	Final Environmental Impact Statement
FEMA	Federal Emergency Management Agency
FFG	Frigate
FHA	Federal Housing Administration
FICUN	Federal Interagency Committee On Urban Noise
FIP	Federal Implementation Plan
FIREX	Fire Support
FIRP	Flood Insurance Rate Map
FISC	Fleet and Industrial Supply Center
FHA	Federal Housing Administration
FL	Flight Level

FM	Frequency Modulated
FMC	Fishery Management Council
FMP	Fishery Management Plan
FONSI	Finding of No Significant Impact
FP	Force Protection
FP	fibropapillomatosis
FR	Federal Register
FRP	Facility Response Plan
FRTP	Fleet Response Training Plan
FSAR	Finegayan Small Arms Ranges
FSM	Federated States of Micronesia
ft	feet
ft^2	square feet
FTX	Field Training Exercise
FUTR	Fixed Underwater Tracking Range
FY	Fiscal Year
FY04 NDAA	National Defense Authorization Act For Fiscal Year 2004
g	gram
GBU	Guided Bomb Unit
GCA	Guam Code Annotated
GCA	Ground Controlled Approach
GCE	Ground Combat Element
GCMP	Guam Coastal Management Plan
GDEM	Generalized Digital Environmental Model
GDP	Gross Domestic Product
GEPA	Guam Environmental Protection Agency
GIAA	Guam International Airport Authority
GIAT	Guam International Air Terminal
GJMMP	Guam Joint Military Master Plan
GLUP	Guam Land Use Plan
GNWR	Guam National Wildlife Refuge
GovGuam	Government of Guam
GUANG	Guam Air National Guard
GUARNG	Guam Army National Guard
GUNEX	Gunnery Exercise
GVB	Guam Visitors Bureau
HABS	Historic American Building Survey
HADR	Humanitarian and Disaster Relief
HAER	Historic American Engineering Record
HAPC	Habitat Areas of Particular Concern
HARM	High Speed Anti-radiation Missile
HC	Helicopter Coordinator
HC(A)	Helicopter Coordinator (Airborne)
HCN	Hydrogen Cyanide
HE	High Explosive
HELO	Helicopter
HFA	High-Frequency Active
HFBL	High-Frequency Bottom Loss
HH	Helicopter Designation (Typically Search/Rescue/Medical Evacuation))
HMMWV	High Mobility Multipurpose Wheeled Vehicle
HMX	High Melting Explosive
HPA	Hypothalamic-pituitary-adrenal
HPO	Historic Preservation Officer
hr	hour
HRST	Helicopter Rope Suspension Training
HSC	Helicopter Sea Combat
HSWA	Hazardous and Solid Waste Act
HUD	Department of Housing and Urban Development
Hz	hertz
IAH	Inner Apra Harbor
IBB	International Broadcasting Bureau
ICAP	Improved Capability
ICMP	Integrated Comprehensive Monitoring Program
ICRMP	Integrated Cultural Resource Management Plan
ICWC	International Whaling Commission
IED	Improvised Explosive Device
IEER	Improved Extended Echo Ranging
IFR	Instrument Flight Rules
IHA	Incidental Harassment Authorization
III MEF	Third Marine Expeditionary Force
in.	inch
in^3	cubic inch
INRMP	Integrated Natural Resource Management Plan
IOC	Initial Operating Capability
IP	Implementation Plan
IR	infrared
ISR	Intelligence, Surveillance, and Reconnaissance
ISR/Strike	Intelligence, Surveillance, and Reconnaissance/Strike
IUCN	The World Conservation Union
IWC	International Whaling Commission
JDAM	Joint Direct Attack Munition
JFCOM	Joint Forces Command
JGPO	Joint Guam Program Office
JLOTS	Joint Logistics over the shore
JNTC	Joint National Training Capability
JSOW	Joint Stand-Off Weapon
JTFEX	Joint Task Force Exercise
JUCAS	Joint Unmanned Combat Air System
KD	Known Distance
KE	Kinetic Energy
kg	kilogram
kHz	kilohertz
km	kilometer
km^2	square kilometer
kts	knots
LAV	Light Armored Vehicle
lb	pound
LBA	Lease Back Area
LCAC	Landing Craft Air Cushion
LCE	Logistics Combat Element
LCS	Littoral Combat Ship
LCU	Landing Craft Utility
LFA	Low-Frequency Active
LFBL	Low-Frequency Bottom Loss
L_{eq}	Equivalent Sound Level
LHA	Amphibious Assault Ship
LHD	Amphibious Assault Ship
L_{max}	Maximum Sound Level
LGB	Laser Guided Bomb
LGTR	Laser Guided Training Round
LMRS	Long-Term Mine Reconnaissance System
ln	natural log
LOA	Letter of Agreement
LOA	Letter of Authorization
LPD	Amphibious Transport Dock
LSD	Amphibious Assault Ship
LZ	Landing Zone
m	meters
m^2	square meters
m^3	cubic meters

M-4	Assault Rifle
M-16	Assault Rifle
M-203	40 mm Grenade Launcher
M-240G	Medium Machine Gun
M-249 SAW	Light Machine Gun, Squad Automatic Weapon
MAGTF	Marine Air Ground Task Force
MARPOL 73/78	Marine Pollution Convention '73, modified in '78
MAW	Marine Air Wing
MBTA	Migratory Bird Treaty Act
MCM	Mine Countermeasure
MCMEX	Mine Exercise
MEDEVAC	Medical Evacuation
MEF	Marine Expeditionary Force
MEMC	Military Expended Material Constituent
METOC	Meteorological and Oceanographic Operations
MEU	Marine Expeditionary Unit
MFA	Mid-Frequency Active
MFAS	Medium-Frequency Active Sonar
MG	Machine Gun
mgd	million gallons per day
mg/L	milligrams per liter
MH	Helicopter Designation (Typically Multi-mission)
MHWM	Mean High Water Mark
mi.	miles
mi^2	square miles
MI	Maritime Interdiction
min	minutes
MINEX	Mine Laying Exercise
MIO	Maritime Interception Operation
MIRC	Mariana Islands Range Complex
MISSILEX	Missile Exercise
MISTCS	The Mariana Islands Sea Turtle and Cetacean Survey
MIW	Mine Warfare
MLA	Military Lease Area
mm	millimeters
MMA	Multi-mission Maritime Aircraft
MMHSRA	Marine Mammal Health and Stranding Response Act
MMHSRP	Marine Mammal Health and Stranding Response Program
MMPA	Marine Mammal Protection Act
MMR	Military Munitions Rule
MOA	Military Operations Area
MOA	Memorandum of Agreement
MOU	Memorandum of Understanding
MOUT	Military Operations in Urban Terrain
MPA	Maritime Patrol Aircraft
MPRSA	Marine Protection, Research, and Sanctuaries Act
MRA	Marine Resources Assessment
MRUUV	Mission Reconfigurable Unmanned Undersea Vehicle
MSA	Munitions Storage Area
MSE	Multiple Successive Explosions
MSFCMA	Magnuson-Stevens Fishery Conservation and Management Act
MSL	Mean Sea Level
MSS	Mobile Security Squadron
MTH	Marianas Training Handbook
MVA	Marianas Visitors Authority
MWR	Morale, Welfare, and Recreation
NA	Not Applicable
NAAQS	National Ambient Air Quality Standards
NAS	Naval Air Station
NAS	National Academies of Science
NATO	North Atlantic Treaty Organization
NAVBASE	Naval Base
NAVFAC PAC	Naval Facilities Engineering Command Pacific
NAVMAG	Naval Magazine
NAVSTA	Naval Station
NAWQC	National Ambient Water Quality Criteria
NCA	National Command Authority
NCRD	No Cultural Resource Damage
NCTAMS	Naval Communications Area Master Station
NCTS	Naval Computers and Telecommunications Station
NDAA	National Defense Authorization Act
NDE	National Defense Exemption
NEC	North Equatorial Current
NECC	Navy Expeditionary Combat Command
NEO	Noncombatant Evacuation Operations
NEPA	National Environmental Policy Act
NEW	Net Explosive Weight
NHL	National Historic Landmark
NHPA	National Historic Preservation Act
NITTRSS	Navy Integrated Training and Test Range Strategic Study
NLNA	Northern Land Navigation Area
nm	nautical mile
nm^2	square nautical mile
NMFS	National Marine Fisheries Service
NMMTB	National Marine Mammal Tissue Bank
NO_2	Nitrogen Dioxide
NO_x	Oxides of Nitrogen
NOAA	National Oceanic and Atmospheric Administration
NOI	Notice of Intent
NOTAM	Notice to Airmen
NOTMAR	Notice to Mariners
NPAL	North Pacific Acoustic Laboratory
NPDES	National Pollutant Discharge Elimination System
NPS	National Park Service
NRC	National Research Council
NRFCC	National Recreational Fisheries Coordination Council
NRHP	National Register of Historic Places
NRIS	National Register Information System
NRL	Naval Research Laboratory
NS	Naval Station
NSCT	Naval Special Clearance Team
NSFS	Naval Surface Fire Support
NSR	New Source Review
NSW	Naval Special Warfare
NSWG	Naval Special Warfare Group
NSWU	Naval Special Warfare Unit

NT	No Training
NUWC	Naval Undersea Warfare Center
NVG	Night Vision Goggle
NWD	No Wildlife Disturbance
NWF	Northwest Field
NWR	National Wildlife Refuge
NZ	Noise Zones
O_3	Ozone
OABH	Ordnance Annex Breacher House
OAEDS	Ordnance Annex Emergency Detonation Site
OAH	Outer Apra Harbor
OAMCM	Organic Airborne Mine Countermeasure
OCE	Officer-In-Charge of the Exercise
OEA	Overseas Environmental Assessment
OEIS	Overseas Environmental Impact Statement
OLF	Outlying Landing Field
OP	Orote Point
OPA	Oil Pollution Act
OPAREA	Operating Area
OPCQC	Orote Point Close Quarters Combat
OPFOR	Opposition Forces
OPKDR	Orote Point Known Distance Range
OPNAV	Office of the Chief of Naval Operations
OPNAVINST	Chief of Naval Operations Instruction
OPS	Operations
OR	Oregon
ORMA	Ocean Resources Management Act
OSS	Operations Support Squadron
OTB	Over-the-Beach
OTH	Over the Horizon
Pa	Pascal
PA	Programmatic Agreement
Pa•s	Pascal•seconds
PACAF	Pacific Air Forces
PACFIRE	Pre-action Calibration Firing
PACOM	U.S. Pacific Command
PAG	Port Authority of Guam
PAH	Polycyclic Aromatic Hydrocarbons
Pb	Lead
PCB	Polychlorinated Biphenyl
PETN	Pentaerythritol Tetranitrate
pH	Hydrogen Ion Concentration
PIFSC	Pacific Islands Fisheries Science Center
PIRO	Pacific Islands Regional Office
PL	Public Law
$PM_{2.5}$	Particulate Matter 2.5 Microns in Diameter
PM_{10}	Particulate Matter 10 Microns in Diameter
PMAR	Primary Mission Area
POL	Petroleum, Oils, and Lubricants
POW	Prisoner of War
PPA	Pollution Prevention Act
ppb	parts per billion
PPF	Polaris Point Field
ppm	parts per million
psf	pounds per square foot
psi	pounds per square inch
psi-ms	pounds per square inch - milliseconds
PTP	Pre-deployment Training Phase
PTS	Permanent Threshold Shift
PUTR	Portable Underwater Tracking Range
PWC	Public Works Center
PWSS	Public Water Supply Systems
QDR	Quadrennial Defense Review
R-	Restricted Area
R&S	Reconnaissance and Surveillance
RAICUZ	Range Air Installations Compatible Use Zones
RCA	Range Condition Assessment
RCB	Reserve Craft Beach
RCD	Required Capabilities Document
RCMP	Range Complex Management Plan
RCRA	Resource Conservation and Recovery Act
RDT&E	Research, Development, Test, and Evaluation
RDX	Royal Demolition Explosive
re 1 μPa-m	referenced to 1 micropascal at 1 meter
RED HORSE	Rapid Engineer Deployable Heavy Operational Repair Squadron Engineer
REXTORP	Recoverable Exercise Torpedo
RFRCP	Recreational Fisheries Resources Conservation Plan
RHA	Rivers and Harbors Act
RHIB	Rigid Hull Inflatable Boat
RICRMP	Regional Integrated Cultural Resources Management Plan
RIMPAC	Rim of the Pacific
RL	Received Level
rms	root mean square
RNM	Rotorcraft Noise Model
ROD	Record of Decision
ROWPU	Reverse Osmosis Water Purification Unit
RSIP	Regional Shore Infrastructure Plan
RSO	Range Safety Officer
S-A	Surface-to-Air
S-S	Surface-to-Surface
S&R	Surveillance and Reconnaissance
SACEX	Supporting Arms Coordination Exercise
SAM	Surface-to-Air Missile
SAMEX	Surface-to Air Missile Exercise
SAR	Search and Rescue
SARS	Severe Acute Respiratory Syndrome
SAW	Squad Automatic Weapon
SBU	Special Boat Unit
SCD	Silicate Compensation Depth
SCUBA	Self-Contained Underwater Breathing Apparatus
SD	Standard Deviation
SDV	SEAL Delivery Vehicle
SDWA	Safe Drinking Water Act
SEAD	Suppression of Enemy Air Defense
SEAL	Sea, Air, and Land Forces
sec	second
§	Section
SEIS	Supplemental Environmental Impact Statement
SEL	Sound Exposure Level
SEPA	State Environmental Policy Act
SFCP	Shore Fire Control Parties
SFS	Security Forces Squadron
SH	Helicopter Designation (Typically Anti-Submarine)
SHAREM	Ship ASW Readiness and Evaluation Measuring
SHPO	State Historic Preservation Officer
SINKEX	Sinking Exercise
SIP	State Implementation Plan

SLAM-ER	Stand-off Land Attack Missile - Extended Range
SLC	Submarine Learning Center
SLNA	Southern Land Navigation Area
SM	Standard Missile
SMA	Shoreline Management Act
SNS	Sympathetic Nervous System
SO_2	Sulfur Dioxide
SOCAL	Southern California
SOC	Special Operations Capable
SOCEX	Special Operations Capable Exercise
SOF	Special Operations Forces
SONAR	Sound Navigation and Ranging
SOP	Standard Operating Procedure
SPCC	Spill Prevention, Control, and Countermeasure
SPIE	Special Purpose Insertion and Extraction
SPL	Sound Pressure Level
SPMAGTF	Special Purpose Marine Air Ground Task Force
SPORTS	Sonar Positional Reporting System
sqrt	Square Root
SRBOC	Super Rapid Bloom Off-board Chaff
SRF	Ship Repair Facility
SRP	Scientific Research Program
SSBN	Ship, Submersible, Ballistic, Nuclear (Submarine)
SSC	SPAWAR Systems Center
SSG	Surface Strike Group
SSGN	Guided Missile Submarine
SSN	Fast Attack Submarine
SSN	Nuclear Submarine
STD	Standard
STOM	Ship to Objective Maneuver
STW	Strike Warfare
SUA	Special Use Airspace
SURC	Small Unit River Craft
SURTASS	Surveillance Towed-Array Sensor System
SUS	Signal Underwater Sound
SUW	Surface Warfare
SVP	Sound Velocity Profile
SWFSC	Southwest Fisheries Science Center
SWPPP	Storm Water Pollution Prevention Plans
T&E	Threatened and Endangered Species
TACP	Tactical Air Control Party
TALD	Tactical Air-Launched Decoy
TAP	Tactical Training Theater Assessment And Planning
TDU	Target Drone Unit
TGEX	Task Group Exercise
TM	Tympanic Membrane
TMDL	Total Maximum Daily Loads
TNT	Trinitrotoluene
TORPEX	Torpedo Exercise
TP	Training Projectile
TRACKEX	Tracking Exercise
TRUEX	Training in Urban Environment Exercise
TS	Threshold Shift
TSCA	Toxic Substances Control Act
TSPI	Time, Space, Position, Information
TSV	Training Support Vessel
TTS	Temporary Threshold Shift
UAS	Unmanned Aerial System
UAV	Unmanned Aerial Vehicle
UCRMP	Updated Cultural Resources Management Plan
UDP	Unit Deployment Program
UJTL	Universal Joint Task List
ULT	Unit-level Training
UME	Unusual Mortality Event
UN	United Nations
UNDET	Underwater Detonations
U.S.	United States
USACE	United States Army Corps of Engineers
USAF	United States Air Force
USC	United States Code
USCG	United States Coast Guard
USCINCPAC REP	Commander In Chief, U.S. Pacific Command Representative
USCINCPAC REP GUAM/CNMI	Commander In Chief, U.S. Pacific Command Representative Guam and the Commonwealth of the Northern Mariana Islands
USDA	United States Department of Agriculture
USDA WS	United States Department of Agriculture Wildlife Services
USEPA	United States Environmental Protection Agency
USFF	United States Fleet Forces
USFWS	United States Fish and Wildlife Service
USGS	United States Geological Survey
USGS – BRD	United States Geological Survey Biological Resources Division
USMC	United States Marine Corps
USNS	U.S.Naval Ship
USPACOM	United States Pacific Command
USWEX	Undersea Warfare Exercise
USWTR	Undersea Warfare Training Range
UTR	Underwater Tracking Range
UUV	Unmanned Underwater Vehicle
UXO	Unexploded Ordnance
V&VE	coastal flood hazard zones
VAST-IMPASS	Virtual At-Sea Training Integrated Maritime Portable Acoustic Scoring and Simulator
VBSS	Visit, Board, Search, and Seizure
VFR	Visual Flight Rules
VoA-IBB	Voice of America - International Broadcasting Bureau
VOC	Volatile Organic Compounds
VTNF	Variable Timed, Non-Fragmentation
VTOL	Vertical Takeoff and Landing
VTUAV	Vertical Take-off and Land UAV
W-	Warning Area
WestPac	Western Pacific
WISS	Weapons Impact Scoring System
WPRFMC	Western Pacific Regional Fisheries Management Council
WS	Wildlife Service
WWII	World War Two
ZOI	Zone of Influence

CHAPTER 4 OTHER CONSIDERATIONS

4.1 CONSISTENCY WITH OTHER FEDERAL, STATE, AND LOCAL PLANS, POLICIES, AND REGULATIONS

Based on evaluation with respect to consistency and statutory obligations, the Navy's Proposed Action and Alternatives for the Mariana Islands Range Complex (MIRC) Environmental Impact Statement/Overseas Environmental Impact Statement (EIS/OEIS) does not conflict with the objectives or requirements of federal, state, regional, or local plans, policies, or legal requirements. Table 4-1 provides a summary of environmental compliance requirements that may apply. *As of the date of this document, none of the analysis indicates an inconsistency with environmental compliance requirements that may apply to this Proposed Action and Alternatives. This table will be updated as public involvement and additional analysis is completed. This table will be in final format before publication to the public.*

Table 4-1: Summary of Environmental Compliance for the Proposed Action

Plans, Policies, and Controls	Responsible Agency	Status of Compliance
National Environmental Policy Act (NEPA) of 1969 (42 USC §§ 4321, *et seq.*) **Council on Environmental Quality (CEQ)** **Regulations for Implementing the Procedural Provisions of NEPA (40 CFR §§ 1500-1508)** **DoN Procedures for Implementing NEPA (32 CFR § 775)**	Navy Marines Air Force Army	This EIS/OEIS has been prepared in accordance with NEPA, CEQ regulations and the Services' NEPA procedures. Public participation and review is being conducted in compliance with NEPA. The Proposed Action would not result in significant impacts.
Clean Water Act (CWA) (33 USC §§ 1344, *et seq.*)	USEPA	No permit under the CWA, whether under Section 401, 402, or 404 (b) (1), is required.
Executive Order (EO) 12114, Environmental Effects Abroad of Major Federal Actions	Navy Marines Air Force Army	EO 12114 requires environmental consideration for actions that may affect the environment outside of U.S. Territorial Waters. The Proposed Action would not result in significant harm to the environment.

Table 4-1: Summary of Environmental Compliance for the Proposed Action (continued)

Plans, Policies, and Controls	Responsible Agency	Status of Compliance
Coastal Zone Management Act (CZMA) (16 CFR §§ 1451, *et seq.*)	Bureau of Statistics and Plans - Guam Coastal Resources Management Office - CNMI	The Navy has determined that the Proposed Action is consistent to the maximum extent practicable with the Guam and CNMI Coastal Management Plans, and is preparing Coastal Consistency Determinations (CCD) in accordance with the CZMA.
Magnuson-Stevens Fishery Conservation and Management Act (16 USC §§ 1801-1802)	National Marine Fisheries Service (NMFS)	The Proposed Action would not adversely affect Essential Fish Habitat (EFH) and would not decrease the available area or quality of EFH.
Endangered Species Act (ESA) (16 USC §§ 1531, *et seq.*)	U.S. Fish and Wildlife Service (USFWS) NMFS	The EIS/OEIS analyzes potential effects to species listed under the ESA. The Navy will complete consultation under Section 7 of the ESA with NMFS and USFWS on the potential that the Proposed Action may affect listed species.
The National Marine Sanctuaries Act (16 USC §§ 1431, *et. seq.*)	National Oceanic and Atmospheric Administration	The Proposed Action would have no effect on sanctuary resources in the off-shore environment of the Study Area. Review of agency actions under Section 304 is not required.
Marine Mammal Protection Act (MMPA) (16 USC §§ 1431, *et seq.*)	NMFS	This EIS/OEIS analyzes potential effects to marine mammals, some of which are species-listed under the ESA. As noted, potential effects on listed species are the subject of consultations with NMFS. The Navy will also prepare a request for a Letter of Authorization from the NMFS regarding effects on marine mammals.

Table 4-1: Summary of Environmental Compliance for the Proposed Action (continued)

Plans, Policies, and Controls	Responsible Agency	Status of Compliance
National Historic Preservation Act (NHPA) (16 USC §§ 470, *et seq.*)	Navy Marines Air Force Army	The Services comply with the consultation and other requirements of the NHPA. The Proposed Action would not have a significant impact on protected resources. The Navy, Air Force, and the Cultural Resources Partners (Advisory Council of Historic Preservation, Guam Historic Preservation Officer, and CNMI Historic Preservation Officer) are in negotiation on a new Programmatic Agreement for all military training in the Marianas covered in this EIS/OEIS.
EO 12898, Federal Actions to Address Environmental Justice in Minority Populations and Low-Income Populations	Navy Marines Air Force Army	The Proposed Action would not result in disproportionately high and adverse human health or environmental effects on minority or low income populations.
EO 13045, Protection of Children from Environmental Health Risks and Safety Risks	Navy Marines Air Force Army	The Proposed Action would not result in disproportionate risks to children from environmental health risks or safety risks.
EO 13112, Invasive Species	Navy Marines Air Force Army	EO 13112 requires Agencies to identify actions that may affect the status of invasive species and take measures to avoid introduction and spread of those species. This EIS/OEIS satisfies the requirement of EO 13112 with regard to the Proposed Action.
EO 11990, Protection of Wetlands	Navy Marines Air Force Army	The Proposed Action would not have a significant impact on wetlands.

Table 4-1: Summary of Environmental Compliance for the Proposed Action (continued)

Plans, Policies, and Controls	Responsible Agency	Status of Compliance
EO 12962, Recreational Fisheries	Navy Marines Air Force Army	EO 12962 requires Agencies to fulfill certain duties with regard to promoting the health and access of the public to recreational fishing areas. The Proposed Action complies with these duties.
Migratory Bird Treaty Act (MBTA) (16 USC §§703-712)	USFWS	The Proposed Action would not have a significant impact on migratory birds, and would comply with applicable requirements of the MBTA.
The Sikes Act of 1960 (16 USC §§670a-670o, as amended by the Sikes Act Improvement Act of 1997, Public Law No. 105-85) requires military installations with significant natural resources, to prepare and implement Integrated Natural Resource Management Plans (INRMP).	Navy Marines Air Force Army	The Proposed Action would be implemented in accordance with the management and conservation criteria developed in the INRMPs for MIRC. The Proposed Action and Alternatives will not result in a requirement for an update of INRMPs outside of their normal update schedule of every 5 years.

4.2 RELATIONSHIP BETWEEN SHORT-TERM USE OF MAN'S ENVIRONMENT AND MAINTENANCE AND ENHANCEMENT OF LONG-TERM PRODUCTIVITY

NEPA requires analysis of the relationship between a project's short-term impacts on the environment and the effects that those impacts may have on the maintenance and enhancement of the long-term productivity of the affected environment. Impacts that narrow the range of beneficial uses of the environment are of particular concern. This means that choosing one option may reduce future flexibility in pursuing other options, or that committing a resource to a certain use may often eliminate the possibility for other uses of that resource.

With respect to marine mammals, the Services, in partnership with the National Marine Fisheries Service (NMFS), are committed to furthering understanding of these creatures and developing ways to lessen or eliminate the impacts DoD training activities may have on these animals.

The Proposed Action would result in both short- and long-term environmental effects. However, the Proposed Action would not be expected to result in any impacts that would reduce environmental productivity, permanently narrow the range of beneficial uses of the environment, or pose long-term risks to health, safety, or general welfare of the public. The Services are committed to sustainable range management, including co-use of the MIRC with general public and commercial interests. This commitment to co-use will enhance long-term productivity of the range areas within the MIRC.

4.3 IRREVERSIBLE OR IRRETRIEVABLE COMMITMENT OF RESOURCES

NEPA requires that environmental analysis include identification of "any irreversible and irretrievable commitments of resources which would be involved in the Proposed Action should it be implemented." Irreversible and irretrievable resource commitments are related to the use of non-renewable resources and the effects that the uses of these resources have on future generations. Irreversible effects primarily result from the use or destruction of a specific resource (*e.g.,* energy or minerals) that cannot be replaced within a reasonable time frame. Irretrievable resource commitments involve the loss in value of an affected resource that cannot be restored as a result of the action (*e.g.,* the disturbance of a cultural site).

For the Proposed Action and Alternatives, most resource commitments are neither irreversible nor irretrievable. Most impacts are short-term and temporary, or long lasting but negligible. Culturally significant resources that are known to occur in the area proposed for training activities have protective measures in place for sensitive areas, therefore, there will be no adverse effect on historic properties. No habitat associated with threatened or endangered species would be lost as result of implementation of the Proposed Action. Since there would be no building or facility construction, the consumption of materials typically associated with such construction (*e.g.,* concrete, metal, sand, fuel) would not occur. Energy typically associated with construction activities would not be expended and irreversibly lost. Implementation of the Proposed Action would require fuels used by aircraft, ships, and ground-based vehicles. Since fixed- and rotary-wing flight and ship activities could increase relative to what is currently experienced, total fuel use would increase. Fuel use by ground-based vehicles involved in training activities would also increase. Therefore, total fuel consumption would increase and this nonrenewable resource would be considered irretrievably lost.

4.4 ENERGY REQUIREMENTS AND CONSERVATION POTENTIAL OF ALTERNATIVES AND MITIGATION MEASURES

Increased training and testing operations on the MIRC would result in an increase in energy demand over the No Action Alternative. This would result in an increase in fossil fuel consumption, mainly from aircraft, vessels, ground equipment, and power supply. Although the required electricity demands of increased intensity of land-use would be met by the existing electrical generation infrastructure at the MIRC, the alternatives would result in a net cumulative negative impact on the energy supply.

Energy requirements would be subject to any established energy conservation practices at each facility. No additional power generation capacity other than the potential use of generators would be required for any of the training activities. The use of energy sources has been minimized wherever possible without compromising safety, training, or testing operations.

At the present time, the Services, under the direction of the Energy Policy Act (EPAct) of 1992 and EO 13149, is actively testing and introducing several different types of alternate fuels (bio-diesel B100/B20, clean natural gas, fuel ethanol E85, fuel cells, *etc.*) to further reduce the impacts of its activities on the environment and non-renewable resources.

4.5 NATURAL OR DEPLETABLE RESOURCE REQUIREMENTS AND CONSERVATION POTENTIAL OF VARIOUS ALTERNATIVES AND MITIGATION MEASURES

Resources that would be permanently and continually consumed by project implementation include water, electricity, natural gas, and fossil fuels; however, the amount and rate of consumption of these resources would not result in significant environmental impacts or the unnecessary, inefficient, or wasteful use of resources. Nuclear powered vessels would be a benefit as they decrease the use of fossil fuels. In addition, construction activities related to increased training and testing operations on the MIRC would result in the irretrievable commitment of nonrenewable energy resources, primarily in the form of fossil fuels (including fuel oil), natural gas, and gasoline construction equipment. With respect to training activities, compliance with all applicable building codes, as well as project mitigation measures, would ensure that all natural resources are conserved or recycled to the maximum extent feasible. It is also possible that new technologies or systems would emerge, or would become more cost effective or user-friendly, which would further reduce reliance on nonrenewable natural resources. However, even with implementation of conservation measures, consumption of natural resources would generally increase with implementation of the alternatives.

Aircraft training activities within the MIRC airspace are the single largest airborne noise source. Noise levels in excess of 90 decibels can occur. Protective measures (structural attenuation features) are in place. Sustainable range management practices are in place that protect and conserve natural and cultural resources as well as preserve access to training areas for current and future training requirements, while addressing potential encroachments that threaten to impact range capabilities.

4.6 URBAN QUALITY, HISTORIC AND CULTURAL RESOURCES, AND THE DESIGN OF THE BUILT ENVIRONMENT

There are no urban areas under consideration in this EIS/OEIS and therefore no urban quality issues exist. Likewise, there is no new construction being proposed. Historic and cultural resources are addressed in Section 3.13.

CHAPTER 5 MITIGATION MEASURES

As part of the Navy's commitment to sustainable use of resources and environmental stewardship, the Navy incorporates measures that are protective of the environment into all of its activities. These include employment of best management practice, standard operating procedures (SOPs), adoption of conservation recommendations, and other measures that mitigate the impacts of Navy activities on the environment. Some of these measures are generally applicable and others are designed to apply to certain geographic areas during certain times of year, for specific types of military training. Mitigation measures covering habitats and species occurring in the Mariana Islands Range Complex have been developed through various environmental analyses conducted by the Navy for land and sea ranges and adjacent coastal waters.

The Navy has implemented a variety of marine mammal mitigation measures over the last two decades. The following discussion briefly describes the genesis and status of those mitigation measures.

Since the 1990s, the Navy has developed and implemented mitigation measures either as a result of environmental analysis or in consultation with regulatory agencies for research, development, test, and evaluation activities (RDT&E) and training exercises. These measures included visual detection by trained lookouts, power down and shut down procedures, the use of passive sensors to detect marine mammals, and avoidance of marine mammals.

In December 2000, the Navy issued a memorandum entitled "Compliance with Environmental Requirements in the Conduct of Naval Exercises or Training at Sea" (DoN, 2000). This memorandum clarified Navy policy for continued compliance with certain environmental requirements including preparation of environmental planning documents, consultations pursuant to the Endangered Species Act (ESA), and applications for "take" authorizations under the Marine Mammal Protection Act (MMPA).

In 2003, the Navy issued the Protective Measures Assessment Protocol (PMAP) that implemented Navy-wide mitigation measures for various types of routine training events. Following the implementation of PMAP, the Navy agreed to additional mitigation measures as part of MMPA authorization and ESA consultation processes for specific training exercises from 2004-2007.

In order to make the findings necessary to issue the MMPA authorization, it may be necessary for the National Marine Fisheries Service (NMFS) to require additional mitigation or monitoring measures beyond those addressed in this Environmental Impact Statement (EIS)/Overseas Environmental Impact Statement (OE(S) (hereafter referred to as "EIS/OEIS"). These could include measures considered, but eliminated in this EIS/OEIS, or as yet undeveloped measures. In addition to commenting on this EIS/OEIS, the public will have an opportunity to provide information to NMFS through the MMPA process, both during the comment period following NMFS' Notice of Receipt of the application for a Letter of Authorization (LOA), and during the comment period following publication of the proposed rule. NMFS may propose additional mitigation or monitoring measures in the proposed rule. The suite of measures developed to date as a result of those MMPA processes are included and analyzed as part of this section.

Additionally, the Navy is engaging in consultation processes under the ESA with regard to listed species that may be affected by the activities described in this EIS/OEIS. For the purposes of the ESA section 7 consultation, the mitigation measures proposed here may be considered by NMFS as beneficial actions taken by the Federal agency or applicant (50 CFR 402.14[g][8]). If required to satisfy requirements of the ESA, NMFS may develop an additional set of measures contained in Reasonable and Prudent

Alternatives, Reasonable and Prudent Measures, or Conservation Recommendations in any Biological Opinion issued for this Proposed Action.

The Navy also will consider public comments on proposed mitigation measures described in this EIS/OEIS.

This Section describes mitigation measures applicable to military service activities in the Mariana Islands Range Complex.

5.1 WATER QUALITY

Navy activities could result in environmental effects on water quality in ocean areas due to shipboard training, expenditure of ordnance, and training-related debris such as used targets. Navy ships are required to conduct activities at sea in a manner that minimizes or eliminates any adverse impacts on the marine environment. Environmental compliance policies and procedures applicable to shipboard training afloat and pollution prevention are defined in Navy instructions, DoD Instruction 5000.2-R, Executive Order (E.O.) 12856, and E.O. 13101. These instructions reinforce the Clean Water Act's prohibition against discharge of harmful quantities of hazardous substances into or upon U.S. waters out to 200 nm (371 km), and mandate stringent hazardous waste discharge, storage, dumping, and pollution prevention requirements. Navy Standard Operating Procedures and Best Management Practices for shipboard management, storage, and discharge of hazardous materials and wastes, and other pollution protection measures are intended to protect water quality.

Governing procedures for the use of training areas, ranges and airspace operated and controlled by the Commander U.S. Naval Forces, Marianas including instructions and procedures for the use of Guam, Saipan, Tinian, Rota and Farallon de Medinilla are included in COMNAVMARIANAS Instruction 3500.4 (Marianas Training Handbook). This guidance identifies specific land use constraints to enable protection of environmental resources during military training in the MIRC.

5.2 SEA TURTLES AND MARINE MAMMALS

As discussed in Section 3.8 and 3.9, the comprehensive suite of protective measures and SOPs implemented by the Navy to reduce impacts to marine mammals also serves to mitigate potential impacts on sea turtles. In particular, personnel and watchstander training, establishment of turtle-free exclusion zones for underwater detonations of explosives, and pre- and post-exercise surveys, all serve to reduce or eliminate potential impacts of Navy activities on sea turtles that may be present in the vicinity.

Effective training in the MIRC dictates that ship, submarine, and aircraft participants utilize their sensors and exercise weapons to their optimum capabilities as required by the mission. This section is a comprehensive list of mitigation measures that would be utilized for training activities analyzed in the EIS/OEIS in order to minimize potential for impacts on marine mammals and sea turtles in the MIRC.

In addition, marine mammals may be exposed to sound energy levels sufficient to cause a physiological effect. As described in Section 3.7. certain received sound energy levels are associated with temporary threshold shift (TTS), a temporary hearing loss, or permanent threshold shift (PTS), a permanent hearing loss, over a subsection of an animal's hearing range. The mitigation measures described in this section will limit potential exposures within the range of sonar use that could result in physiological effects.

The typical ranges, or distances, from the most powerful and common active sonar sources used in MIRC to received sound energy levels associated with TTS and PTS are shown in Table 5.2-1. Due to spreading loss, sound attenuates logarithmically from the source, so the area in which an animal could be exposed to potential injury (PTS) is small. Because the most powerful sources would typically be used in deep water and the range to effect is limited, spherical spreading is assumed for 195 decibels referenced to 1 micro-Pascal squared second (dB re 1µPa^2-s) and above. Also, due to the limited ranges, interactions with the bottom or surface ducts are rarely an issue.

Table 5.2-1. Range to Effects for Active Sonar

Active Sonar Source	Range To TTS (ft/m)	Range to PTS (ft/m)
SQS-53 ship	459/140	33/10
SQS-56 ship	108/33	11/3.2

Current protective measures employed by the Navy include applicable training of personnel and implementation of activity specific procedures resulting in minimization and/or avoidance of interactions with protected resources.

This section includes protective and mitigation measures that are followed for all types of exercises; those that are associated with a particular type of training event; and those that apply to a particular geographic region or season. For major exercises, the applicable mitigation measures are incorporated into a naval message which is disseminated to all of the units and Services participating in the exercise or training event and applicable responsible commands. and Services. U.S. participants are required to comply with these measures. Non-U.S. participants involved in events within the territorial seas of the U.S. (12 nm) are requested to comply with these measures to the extent these measures do not conflict with Status of Forces Agreements. Non-U.S. participants involved in events beyond the territorial seas (12 nm) are encouraged to comply with these mitigation measures to the extent the measures do not impair training, operations, or operational capabilities.

5.2.1 General Maritime Measures

5.2.1.1 Personnel Training – Watchstanders and Lookouts

The use of shipboard lookouts is a critical component of all Navy protective measures. Navy shipboard lookouts (also referred to as “watchstanders”) are highly qualified and experienced observers of the marine environment. Their duties require that they report all objects sighted in the water to the Officer of the Deck (OOD) (*e.g.*, trash, a periscope, marine mammals, sea turtles) and all disturbances (*e.g.*, surface disturbance, discoloration) that may be indicative of a threat to the vessel and its crew. There are personnel serving as lookouts on station at all times (day and night) when a ship or surfaced submarine is moving through the water.

All Commanding Officers (COs), Executive Officers (XOs), lookouts, OODs, junior OODs (JOODs), maritime patrol aircraft aircrews, and Anti-submarine Warfare (ASW)/Mine Warfare (MIW) helicopter crews will complete the NMFS-approved Marine Species Awareness Training (MSAT) by viewing the U.S. Navy MSAT digital versatile disk (DVD). MSAT may also be viewed on-line at https://portal.navfac.navy.mil/go/msat. All bridge watchstanders/lookouts will complete both parts one and two of the MSAT; part two is options for other personnel. Part 1 of this training addresses the lookout’s role in environmental protection, laws governing the protection of marine species, Navy stewardship commitments and general observation information to aid in avoiding interactions with marine species. Part 2 focuses on identification of specific species.

- Navy lookouts will undertake extensive training in order to qualify as a watchstander in accordance with the Lookout Training Handbook (Naval Education and Training Command [NAVEDTRA] 12968-D).
- Lookout training will include on-the-job instruction under the supervision of a qualified, experienced lookout. Following successful completion of this supervised training period, Lookouts will complete the Personal Qualification Standard program, certifying that they have demonstrated the necessary skills (such as detection and reporting of partially submerged objects). This does not preclude personnel being trained as lookouts from being counted as those listed in previous measures so long as supervisors monitor their progress and performance.
- Lookouts will be trained in the most effective means to ensure quick and effective communication within the command structure in order to facilitate implementation of protective measures if marine species are spotted.

5.2.1.2 Operating Procedures & Collision Avoidance

- Prior to major exercises, a Letter of Instruction, Mitigation Measures Message or Environmental Annex to the Operational Order will be issued prior to the exercise to further disseminate the personnel training requirement and general marine mammal protective measures.
- Commanding Officers will make use of marine species detection cues and information to limit interaction with marine species to the maximum extent possible consistent with safety of the ship.
- While underway, surface vessels will have at least two lookouts with binoculars; surfaced submarines will have at least one lookout with binoculars. Lookouts already posted for safety of navigation and man-overboard precautions may be used to fill this requirement. As part of their regular duties, lookouts will watch for and report to the OOD the presence of marine mammals and sea turtles.
- On surface vessels equipped with a mid-frequency active sonar, pedestal mounted "Big Eye" (20x10) binoculars will be properly installed and in good working order to assist in the detection of marine mammals and sea turtles in the vicinity of the vessel.
- Personnel on lookout will employ visual search procedures employing a scanning methodology in accordance with the Lookout Training Handbook (NAVEDTRA 12968-D).
- While in transit, naval vessels will be alert at all times, use extreme caution, and proceed at a "safe speed" so that the vessel can take proper and effective action to avoid a collision with any marine animal and can be stopped within a distance appropriate to the prevailing circumstances and conditions.
- When marine mammals have been sighted in the area, Navy vessels will increase vigilance and take reasonable and practicable actions to avoid collisions and activities that might result in close interaction of naval assets and marine mammals. Actions may include changing speed and/or direction and are dictated by environmental and other conditions (*e.g.*, safety, weather).
- Naval vessels will maneuver to keep a safe distance from any observed marine mammal and avoid approaching them head-on. This requirement does not apply if a vessel's safety is threatened, such as when change of course will create an imminent and serious threat to a person, vessel, or aircraft, and to the extent vessels are restricted in their ability to maneuver. Restricted maneuverability includes, but is not limited to, situations when vessels are engaged in dredging, submerged operations, launching and recovering aircraft or landing craft, minesweeping operations, replenishment while underway and towing operations that severely restrict a vessel's

ability to deviate course. Vessels will take reasonable steps to alert other vessels in the vicinity of the marine mammal.

- Navy aircraft participating in exercises at sea will conduct and maintain, when operationally feasible and safe, surveillance for marine species of concern as long as it does not violate safety constraints or interfere with the accomplishment of primary operational duties. Marine mammal detections will be immediately reported to assigned Aircraft Control Unit for further dissemination to ships in the vicinity of the marine species as appropriate where it is reasonable to conclude that the course of the ship will likely result in a closing of the distance to the detected marine mammals.
- All vessels will maintain logs and records documenting training activities should they be required for event reconstruction purposes. Logs and records will be kept for a period of 30 days following completion of a major training exercise.

5.2.2 Measures for Specific Training Events

5.2.2.1 Mid-Frequency Active Sonar Operations

5.2.2.1.1 General Maritime Mitigation Measures: Personnel Training

- All lookouts onboard platforms involved in ASW training events will review the NMFS approved MSAT material prior to MFA sonar use.
- All Commanding Officers, Executive Officers, and officers standing watch on the Bridge will have reviewed the MSAT material prior to a training event employing the use of MFA sonar.
- Navy personnel will undertake extensive training in order to qualify as a lookout in accordance with the Lookout Training Handbook (Naval Education and Training [NAVEDTRA] 12968-D).
- Lookout training will include on-the-job instruction under the supervision of a qualified, experienced lookout. Following successful completion of this supervised training period, Lookouts will complete the Personal Qualification Standard program, certifying that they have demonstrated the necessary skills (such as detection and reporting of partially submerged objects). This does not preclude personnel being trained as lookouts from being counted as those listed in previous measures so long as supervisors monitor their progress and performance.
- Lookouts will be trained in the most effective means to ensure quick and effective communication within the command structure in order to facilitate implementation of protective measures if marine species are spotted.

5.2.2.1.2 General Maritime Mitigation Measures: Lookout and Watchstander Responsibilities

- On the bridge of surface ships, there will always be at least three people on watch whose duties include observing the water surface around the vessel.
- All surface ships participating in ASW training events will, in addition to the three personnel on watch noted previously, have at all times during the exercise at least two additional personnel on watch as marine mammal lookouts.
- Personnel on lookout and officers on watch on the bridge will have at least one set of binoculars available for each person to aid in the detection of marine mammals.

- On surface vessels equipped with MFA sonar, pedestal mounted “Big Eye” (20x110) binoculars will be present and in good working order to assist in the detection of marine mammals in the vicinity of the vessel.
- After sunset and prior to sunrise, lookouts will employ Night Lookouts Techniques in accordance with the Lookout Training Handbook. Application of these techniques, which include the use of night vision goggles, allow lookouts to effectively monitor a 1,100 yard (yd) (1,000 meter [m]) safety zone at night.
- Personnel on lookout will be responsible for reporting all objects or anomalies sighted in the water (regardless of the distance from the vessel) to the Officer of the Deck, since any object or disturbance (e.g., trash, periscope, surface disturbance, discoloration) in the water may be indicative of a threat to the vessel and its crew or indicative of a marine species that may need to be avoided as warranted.

5.2.2.1.3 Operating Procedures

- A Letter of Instruction, Mitigation Measures Message or Environmental Annex to the Operational Order will be issued prior to the exercise to further disseminate the personnel training requirement and general marine mammal protective measures.
- Commanding Officers will make use of marine species detection cues and information to limit interaction with marine species to the maximum extent possible consistent with safety of the ship.
- All personnel engaged in passive acoustic sonar operation (including aircraft, surface ships, or submarines) will monitor for marine mammal vocalizations and report the detection of any marine mammal to the appropriate watch station for dissemination and appropriate action.
- During MFA sonar operations, personnel will utilize all available sensor and optical systems (such as night vision goggles) to aid in the detection of marine mammals.
- Navy aircraft participating in exercises at sea will conduct and maintain, when operationally feasible and safe, surveillance for marine species of concern as long as it does not violate safety constraints or interfere with the accomplishment of primary operational duties.
- Aircraft with deployed sonobuoys will use only the passive capability of sonobuoys when marine mammals are detected within 200 yd (183 m) of the sonobuoy.
- Marine mammal detections will be immediately reported to assigned Aircraft Control Unit for further dissemination to ships in the vicinity of the marine species as appropriate where it is reasonable to conclude that the course of the ship will likely result in a closing of the distance to the detected marine mammal.
- Safety Zones—When marine mammals are detected by any means (aircraft, shipboard lookout, or acoustically) within 1,000 yds (914 m) of the sonar dome (the bow), the ship or submarine will limit active transmission levels to at least 6 decibels (dB) below normal operating levels. (A 6 dB reduction equates to a 75 percent power reduction. The reason is that decibel levels are on a logarithmic scale. Thus, a 6 dB reduction results in a power level only 25 percent of the original power.)
  - Ships and submarines will continue to limit maximum MFA transmission levels by this 6-dB factor until the marine mammal has been seen to leave the area, has not been detected for 30 minutes, or the vessel has transited more than 2,000 yds (1,829 m) beyond the location of the last detection.

- Should a marine mammal be detected within or closing to inside 500 yds (457 m) of the sonar dome, active transmissions will be limited to at least 10 dB below the equipment's normal operating level. Ships and submarines will continue to limit maximum ping levels by this 10-dB factor until the marine mammal has been seen to leave the area, has not been detected for 30 minutes, or the vessel has transited more than 2,000 yds (457 m) beyond the location of the last detection.
- Should the marine mammal be detected within or closing to 200 yards of the sonar dome, active sonar transmissions will cease. Sonar will not resume until the animal has been seen to leave the area, has not been detected for 30 minutes, or the vessel has transited more than 2,000 yds (457 m) beyond the location of the last detection.
- Special conditions applicable for dolphins and porpoises only: If, after conducting an initial maneuver to avoid close quarters with dolphins or porpoises, the Officer of the Deck concludes that dolphins or porpoises are deliberately closing to ride the vessel's bow wave, no further mitigation actions are necessary while the dolphins or porpoises continue to exhibit bow wave riding behavior.
- If the need for power-down should arise as detailed in "Safety Zones" above, the Navy shall follow the requirements as though they were operating at 235 dB—the normal operating level (*i.e.*, the first power-down will be to 229 dB, regardless of at what level above 235 dB the sonar was being operated).

- Prior to start up or restart of MFA sonar, operators will check that the Safety Zone radius around the sound source is clear of marine mammals.
- Active sonar levels (generally)**—**the ship or submarine will operate MFA sonar at the lowest practicable level, not to exceed 235 dB, except as required to meet tactical training objectives.
- Helicopters shall observe/survey the vicinity of an ASW exercise for 10 minutes before the first deployment of active (dipping) sonar in the water.
- Helicopters shall not dip their sonar within 200 yds (183 m) of a marine mammal and shall cease pinging if a marine mammal closes within 200 yds (183 m) after pinging has begun.
- Submarine sonar operators will review detection indicators of close-aboard marine mammals prior to the commencement of ASW events involving MFA sonar.
- Increased vigilance during major ASW training with tactical MFA sonar when critical conditions are present.

Based on lessons learned from strandings in the Bahamas (2000), Madeira (2000), the Canaries (2002), and Spain (2006), beaked whales are of particular concern since they have been associated with MFA sonar operations. The Navy should avoid planning major ASW training with MFA sonar in areas where they will encounter conditions that, in their aggregate, may contribute to a marine mammal stranding event.

The conditions to be considered during exercise planning include:

- Areas of at least 1,094 yards (1,000 m depth) near a shoreline where there is a rapid change in bathymetry on the order of 1,000 to 6,000 yards (914 -5,486 meters) occurring across a relatively short horizontal distance (e.g., 5 nautical miles [nm]).
- Cases for which multiple ships or submarines (≥ 3) operating MFA sonar in the same area over extended periods of time (≥ 6 hours) in close proximity (≤ 10 nm apart).

- An area surrounded by land masses, separated by less than 35 nm and at least 10 nm in length, or an embayment, wherein events involving multiple ships/subs (≥ 3) employing MFA sonar near land may produce sound directed toward the channel or embayment that may cut off the lines of egress for marine mammals.
- Though not as dominant a condition as bathymetric features, the historical presence of a strong surface duct (i.e., a mixed layer of constant water temperature extending from the sea surface to 100 or more feet).

If the Major Exercise must occur in an area where the above conditions exist in their aggregate, these conditions must be fully analyzed in environmental planning documentation. The Navy will increase vigilance by undertaking the following additional protective measure:

- A dedicated aircraft (Navy asset or contracted aircraft) will undertake reconnaissance of the embayment or channel ahead of the exercise participants to detect marine mammals that may be in the area exposed to active sonar. Where practical, advance survey should occur within about 2 hours prior to MFA sonar use and periodic surveillance should continue for the duration of the exercise. Any unusual conditions (e.g., presence of sensitive species, groups of species milling out of habitat, and any stranded animals) shall be reported to the Officer in Tactical Command, who should give consideration to delaying, suspending, or altering the exercise.
- All safety zone power-down requirements described in this measure apply.
- The post-exercise report must include specific reference to any event conducted in areas where the above conditions exist, with exact location and time/duration of the event, and noting results of surveys conducted.

5.2.2.2 Surface-to-Surface Gunnery (up to 5-inch explosive rounds)

- For exercises using targets towed by a vessel, target-towing vessels shall maintain a trained lookout for marine mammals and sea turtles when feasible. If a marine mammal or sea turtle is sighted in the vicinity, the tow vessel will immediately notify the firing vessel, which will suspend the exercise until the area is clear.
- A 600 yard (585 m) radius buffer zone will be established around the intended target.
- From the intended firing position, trained lookouts will survey the buffer zone for marine mammals and sea turtles prior to commencement and during the exercise as long as practicable. Due to the distance between the firing position and the buffer zone, lookouts are only expected to visually detect breaching whales, whale blows, and large pods of dolphins and porpoises.
- The exercise will be conducted only when the buffer zone is visible and marine mammals and sea turtles are not detected within it.

5.2.2.3 Surface-to-Surface Gunnery (non-explosive rounds)

- A 200 yard (183 m) radius buffer zone will be established around the intended target.
- From the intended firing position, trained lookouts will survey the buffer zone for marine mammals and sea turtles prior to commencement and during the exercise as long as practicable. Due to the distance between the firing position and the buffer zone, lookouts are only expected to visually detect breaching whales, whale blows, and large pods of dolphins and porpoises.

- If applicable, target towing vessels will maintain a lookout. If a marine mammal or sea turtle is sighted in the vicinity of the exercise, the tow vessel will immediately notify the firing vessel in order to secure gunnery firing until the area is clear.
- The exercise will be conducted only when the buffer zone is visible and marine mammals and sea turtles are not detected within the target area and the buffer zone.

5.2.2.4 Surface-to-Air Gunnery (explosive and non-explosive rounds)

- Vessels will orient the geometry of gunnery exercises in order to prevent debris from falling in the area of sighted marine mammals.
- Vessels will expedite the recovery of any parachute deploying aerial targets to reduce the potential for entanglement of marine mammals and sea turtles.
- Target towing vessel shall maintain a lookout if feasible. If a marine mammal or sea turtle is sighted in the vicinity of the exercise, the tow vessel will immediately notify the firing vessel in order to secure gunnery firing until the area is clear.

5.2.2.5 Air-to-Surface Gunnery (explosive and non-explosive rounds)

- A 200 yard (183 m) radius buffer zone will be established around the intended target.
- If surface vessels are involved, lookout(s) will visually survey the buffer zone for marine mammals and sea turtles prior to and during the exercise.
- Aerial surveillance of the buffer zone for marine mammals and sea turtles will be conducted prior to commencement of the exercise. Aerial surveillance altitude of 500 feet to 1,500 feet (152 – 456 m) is optimum. Aircraft crew/pilot will maintain visual watch during exercises. Release of ordnance through cloud cover is prohibited; aircraft must be able to actually see ordnance impact areas.
- The exercise will be conducted only if marine mammals and sea turtles are not visible within the buffer zone.

5.2.2.6 Small Arms Training (grenades, explosive and non-explosive rounds)

Lookouts will visually survey for marine mammals and sea turtles. Weapons will not be fired in the direction of known or observed marine mammals or sea turtles.

5.2.2.7 Air-to-Surface At-Sea Bombing Exercises (explosive bombs and rockets)

- Ordnance shall not be targeted to impact within 1,000 yards (914 m) of known or observed sea turtles or marine mammals.
- A buffer zone of 1,000 yards (914 m) radius will be established around the intended target.
- Aircraft will visually survey the target and buffer zone for marine mammals and sea turtles prior to and during the exercise. The survey of the impact area will be made by flying at 1,500 feet or lower, if safe to do so, and at the slowest safe speed. Release of ordnance through cloud cover is prohibited; aircraft must be able to actually see ordnance impact areas. Survey aircraft should employ most effective search tactics and capabilities.
- The exercises will be conducted only if marine mammals and sea turtles are not visible within the buffer zone.

5.2.2.8 Air-to-Surface At-Sea Bombing Exercises (non-explosive bombs and rockets)

- If surface vessels are involved, trained lookouts will survey for sea turtles and marine mammals. Ordnance shall not be targeted to impact within 1,000 yds (914 m) of known or observed sea turtles or marine mammals.
- A 1,000 yd (914 m) radius buffer zone will be established around the intended target.
- Aircraft will visually survey the target and buffer zone for marine mammals and sea turtles prior to and during the exercise. The survey of the impact area will be made by flying at 1,500 feet (152 m) or lower, if safe to do so, and at the slowest safe speed. Release of ordnance through cloud cover is prohibited; aircraft must be able to actually see ordnance impact areas. Survey aircraft should employ most effective search tactics and capabilities.
- The exercise will be conducted only if marine mammals and sea turtles are not visible within the buffer zone.

5.2.2.9 Underwater Detonations (up to 20 lb charges)

To ensure protection of marine mammals and sea turtles during underwater detonation training and mining activities, the surveillance area must be determined to be clear of marine mammals and sea turtles prior to detonation. Implementation of the following mitigation measures continue to ensure that marine mammals would not be exposed to temporary threshold shift (TTS), permanent threshold shift (PTS), or injury from physical contact with training mine shapes during Major Exercises.

5.2.2.9.1 Exclusion Zones

All Mine Warfare and Mine Countermeasures training activities involving the use of explosive charges must include exclusion zones for marine mammals and sea turtles to prevent physical and/or acoustic effects on those species. These exclusion zones shall extend in a 700-yard arc radius around the detonation site.

5.2.2.9.2 Pre-exercise Surveillance

For Demolition and Ship Mine Countermeasures training activities, pre-exercise surveillance shall be conducted within 30 minutes prior to the commencement of the scheduled explosive event. The surveillance may be conducted from the surface, by divers, and/or from the air, and personnel shall be alert to the presence of any marine mammal or sea turtle. Should such an animal be present within the surveillance area, the exercise shall be paused until the animal voluntarily leaves the area.

5.2.2.9.3 Post-Exercise Surveys and Reporting

Surveillance within the same radius shall also be conducted within 30 minutes after the completion of the explosive event.

If there is evidence that a marine mammal or sea turtle may have been stranded, injured or killed by the action, Navy training activities will be immediately suspended and the situation immediately reported by the participating unit to the Officer in Charge of the Exercise (OCE), who will follow Navy procedures for reporting the incident to the Commander, Navy Marianas who will contact Commander, Pacific Fleet.

5.2.2.10 Sinking Exercise

The selection of sites suitable for Sinking Exercises (SINKEXs) involves a balance of operational suitability, requirements established under the Marine Protection, Research and Sanctuaries Act (MPRSA) permit granted to the Navy (40 Code of Federal Regulations §229.2), and the identification of areas with a low likelihood of encountering ESA listed species. To meet operational suitability criteria, locations must be within a reasonable distance of the target vessels' originating location. The locations should also be close to active military bases to allow participating assets access to shore facilities. For safety purposes, these locations should also be in areas that are not generally used by non-military air or watercraft. The MPRSA permit requires vessels to be sunk in waters which are at least 2,000 yds (1,839 m) deep and at least 50 nm from land.

In general, most listed species prefer areas with strong bathymetric gradients and oceanographic fronts for significant biological activity such as feeding and reproduction. Typical locations include the shelf-edge.

5.2.2.10.1 SINKEX Mitigation Plan

The Navy has developed range clearance procedures to maximize the probability of sighting any ships or protected species in the vicinity of an exercise, which are as follows:

- All weapons firing would be conducted during the period 1 hour after official sunrise to 30 minutes before official sunset.
- Extensive range clearance operations would be conducted in the hours prior to commencement of the exercise, ensuring that no shipping is located within the hazard range of the longest-range weapon being fired for that event.
- An exclusion zone with a radius of 1.0 nm would be established around each target. This exclusion zone is based on calculations using a 990-pound (lb) H6 net explosive weight high explosive source detonated 5 feet (ft) below the surface of the water, which yields a distance of 0.85 nm (cold season) and 0.89 nm (warm season) beyond which the received level is below the 182 decibels (dB) re: 1 micropascal squared-seconds (μPa^2-s) threshold established for the *WINSTON S. CHURCHILL* (DDG 81) shock trials (DoN, 2001). An additional buffer of 0.5 nm would be added to account for errors, target drift, and animal movements. Additionally, a safety zone, which extends from the exclusion zone at 1.0 nm out an additional 0.5 nm, would be surveyed. Together, the zones extend out 2 nm from the target.
- A series of surveillance over-flights would be conducted within the exclusion and the safety zones, prior to and during the exercise, when feasible. Survey protocol would be as follows:
  - Overflights within the exclusion zone would be conducted in a manner that optimizes the surface area of the water observed. This may be accomplished through the use of the Navy's Search and Rescue Tactical Aid, which provides the best search altitude, ground speed, and track spacing for the discovery of small, possibly dark objects in the water based on the environmental conditions of the day. These environmental conditions include the angle of sun inclination, amount of daylight, cloud cover, visibility, and sea state.
  - All visual surveillance activities would be conducted by Navy personnel trained in visual surveillance. At least one member of the mitigation team would have completed the Navy's marine mammal training program for lookouts.
  - In addition to the overflights, the exclusion zone would be monitored by passive acoustic means, when assets are available. This passive acoustic monitoring would be maintained

throughout the exercise. Potential assets include sonobuoys, which can be utilized to detect vocalizing marine mammals (particularly sperm whales) in the vicinity of the exercise. The sonobuoys would be re-seeded as necessary throughout the exercise. Additionally, passive sonar onboard submarines may be utilized to detect any vocalizing marine mammals in the area. The Officer Conducting the Exercise (OCE) would be informed of any aural detection of marine mammals and would include this information in the determination of when it is safe to commence the exercise.

- On each day of the exercise, aerial surveillance of the exclusion and safety zones would commence 2 hours prior to the first firing.
- The results of all visual, aerial, and acoustic searches would be reported immediately to the OCE. No weapons launches or firing would commence until the OCE declares the safety and exclusion zones free of marine mammals and threatened and endangered species.
- If a protected species observed within the exclusion zone is diving, firing would be delayed until the animal is re-sighted outside the exclusion zone, or 30 minutes have elapsed. After 30 minutes, if the animal has not been re-sighted it would be assumed to have left the exclusion zone. This is based on a typical dive time of 30 minutes for traveling listed species of concern. The OCE would determine if the listed species is in danger of being adversely affected by commencement of the exercise.
- During breaks in the exercise of 30 minutes or more, the exclusion zone would again be surveyed for any protected species. If protected species are sighted within the exclusion zone, the OCE would be notified, and the procedure described above would be followed.
- Upon sinking of the vessel, a final surveillance of the exclusion zone would be monitored for 2 hours, or until sunset, to verify that no listed species were harmed.

* Aerial surveillance would be conducted using helicopters or other aircraft based on necessity and availability. The Navy has several types of aircraft capable of performing this task; however, not all types are available for every exercise. For each exercise, the available asset best suited for identifying objects on and near the surface of the ocean would be used. These aircraft would be capable of flying at the slow safe speeds necessary to enable viewing of marine vertebrates with unobstructed, or minimally obstructed, downward and outward visibility. The exclusion and safety zone surveys may be cancelled in the event that a mechanical problem, emergency search and rescue, or other similar and unexpected event preempts the use of one of the aircraft onsite for the exercise. The exercise would not be conducted unless the exclusion zone could be adequately monitored visually.
* Every attempt would be made to conduct the exercise in sea states that are ideal for marine mammal sighting, Beaufort Sea State 3 or less. In the event of a 4 or above, survey efforts would be increased within the zones. This would be accomplished through the use of an additional aircraft, if available, and conducting tight search patterns.
* The exercise would not be conducted unless the exclusion zone could be adequately monitored visually.
* In the unlikely event that any listed species are observed to be harmed in the area, a detailed description of the animal would be taken, the location noted, and if possible, photos taken. This information would be provided to National Oceanic and Atmospheric Administration (NOAA) Fisheries via the Navy's regional environmental coordinator for purposes of identification.

- An after action report detailing the exercise's time line, the time the surveys commenced and terminated, amount, and types of all ordnance expended, and the results of survey efforts for each event would be submitted to NMFS.

5.2.2.11 Mitigation Measures Related to Explosive Source Sonobuoys (AN/SSQ-110A)

5.2.2.11.1 AN/SSQ-110A Pattern Deployment

- Crews will conduct visual reconnaissance of the drop area prior to laying their intended sonobuoy pattern. This search should be conducted below 500 yards (457 m) at a slow speed, if operationally feasible and weather conditions permit. In dual aircraft operations, crews are allowed to conduct coordinated area clearances.
- Crews shall conduct a minimum of 30 minutes of visual and aural monitoring of the search area prior to commanding the first post detonation. This 30-minute observation period may include pattern deployment time.
- For any part of the briefed pattern where a post (source/receiver sonobuoy pair) will be deployed within 1,000 yards (914 m) of observed marine mammal activity, crews will deploy the receiver ONLY and monitor while conducting a visual search. When marine mammals are no longer detected within 1,000 yards (914 m) of the intended post position, crews will co-locate the explosive source sonobuoy (AN/SSQ-110A) (source) with the receiver.
- When operationally feasible, crews will conduct continuous visual and aural monitoring of marine mammal activity. This is to include monitoring of own-aircraft sensors from first sensor placement to checking off station and out of radio frequency (RF) of these sensors.

5.2.2.11.2 AN/SSQ-110A Pattern Employment

- Aural Detection:
  - Aural detection of marine mammals cues the aircrew to increase the diligence of their visual surveillance.
  - If, following aural detection, no marine mammals are visually detected, then the crew may continue multi-static active search.
- Visual Detection:
  - If marine mammals are visually detected within 1,000 yards (914 m) of the explosive source sonobuoy (AN/SSQ-110A) intended for use, then that payload shall not be detonated. Aircrews may utilize this post once the marine mammals have not been re-sighted for 10 minutes, or are observed to have moved outside the 1,000 yards (914 m) safety buffer.
  - Aircrews may shift their multi-static active search to another post, where marine mammals are outside the 1,000 yards (914 m) safety buffer.

5.2.2.11.3 AN/SSQ-110A Scuttling Sonobuoys

- Aircrews shall make every attempt to manually detonate the unexploded charges at each post in the pattern prior to departing the operations area by using the "Payload 1 Release" command followed by the "Payload 2 Release" command. Aircrews shall refrain from using the "Scuttle" command when two payloads remain at a given post. Aircrews will ensure that a 1,000 yard (914 m) safety buffer, visually clear of marine mammals, is maintained around each post as is done during active search operations.

- Aircrews shall only leave posts with unexploded charges in the event of a sonobuoy malfunction, an aircraft system malfunction, or when an aircraft must immediately depart the area due to issues such as fuel constraints, inclement weather, and in-flight emergencies. In these cases, the sonobuoy will self-scuttle using the secondary or tertiary method.
- Aircrews shall ensure all payloads are accounted for. Explosive source sonobuoys (AN/SSQ-110A) that cannot be scuttled shall be reported as unexploded ordnance via voice communications while airborne, then upon landing via naval message.
- Mammal monitoring shall continue until out of own-aircraft sensor range.

5.2.3 Conservation Measures

5.2.3.1 Adaptive Management

Adaptive management principles consider appropriate adjustments to mitigation, monitoring, and reporting as the outcomes of the Proposed Actions and required mitigation are better understood. NMFS includes adaptive management principles in the regulations for the implementation of the Proposed Action, and any adaptive adjustments of mitigation and monitoring would be led by NMFS via the MMPA process and developed in coordination with the Navy. Continued opportunity for public input would be included via the MMPA process, as appropriate (*i.e.*, via the "Letter of Authorization" process). The intent of adaptive management here is to ensure the continued proper implementation of the required mitigation measures, to conduct appropriate monitoring and evaluation efforts, and to recommend possible adjustments to the mitigation/monitoring/reporting to accomplish the established goals of the mitigation and monitoring which include:

Mitigation

- Avoidance or minimization of injury or death of marine mammals wherever possible
- A reduction in the numbers of marine mammals (total number or number at biologically important time or location to received levels of sound associated with the proposed active sonar activities;
- A reduction in the number of times (total number or number at biologically time or location) individuals would be exposed to received levels;
- A reduction in the intensity of exposures (either total number or number at biologically important time or location) to received levels;
- A reduction in effects to marine mammal habitat, paying special attention to the food base, activities that block or limit passage to or from biologically important areas, permanent destruction of habitat, or temporary destruction/disturbance of habitat during a biologically important time; and
- For monitoring directly related to mitigation – an increase in the probability of detecting marine mammals, thus allowing for more effective implementation of the mitigation measures (shut-down zone, *etc.*).

Monitoring

- An increase in the probability of detecting marine mammals, both within the safety zone (thus allowing for more effective implementation of the mitigation) and in general to generate more data to contribute to the effects analyses.

- An increase in our understanding of how many marine mammals are likely to be exposed to levels of MFA sonar/HFA sonar (or explosives or other stimuli) that we associate with specific adverse effects, such as behavioral harassment, TTS, or PTS.
- An increase in our understanding of how marine mammals respond to MFA sonar/HFA sonar (at specific received levels), explosives, or other stimuli expected to result in take and how anticipated adverse effects on individuals (in different ways and to varying degrees) may impact the population, species, or stock (specifically through effects on annual rates of recruitment or survival).
- An increased knowledge of the affected species.
- An increase in our understanding of the effectiveness of certain mitigation and monitoring measures.

Generally speaking, adaptive management supports the integration of NEPA's principles into the ongoing implementation and management of the Proposed Action, including a process for improving, where needed, the effectiveness of the identified mitigations. Note that any adjustment of mitigation and monitoring would be within the scope of the environmental analyses and considerations presented in this EIS/OEIS.

5.2.3.2 Research

The Navy provides a significant amount of funding and support to marine research. The agency provided 26 million dollars in 2008 (100 million dollars over the past 5 years) to universities, research institutions, Federal laboratories, private companies, and independent researchers around the world to study marine mammals. The Navy sponsors 70 percent of all U.S. research concerning the effects of human-generated sound on marine mammals and 50 percent of such research conducted worldwide. Major topics of Navy-supported research include the following:

- Better understanding of marine species distribution and important habitat areas.
- Developing methods to detect and monitor marine species before, during and after training.
- Understanding the effects of sound on marine mammals, sea turtles, and fish.
- Developing tools to model and estimate potential effects of sound.

This research is directly applicable to Navy training activities, particularly with respect to the investigations of the potential effects of underwater noise sources on marine mammals and other protected species. Proposed training activities employ sonar and underwater explosives, which introduce sound into the marine environment.

The Marine Life Sciences Division of the Office of Naval Research currently coordinates six programs that examine the marine environment and are devoted solely to studying the effects of noise and/or the implementation of technology tools that will assist the Navy in studying and tracking marine mammals. The six programs are as follows:

1. Environmental Consequences of Underwater Sound,
2. Non-Auditory Biological Effects of Sound on Marine Mammals,
3. Effects of Sound on the Marine Environment,
4. Sensors and Models for Marine Environmental Monitoring,
5. Effects of Sound on Hearing of Marine Animals, and
6. Passive Acoustic Detection, Classification, and Tracking of Marine Mammals.

The Navy has also developed the technical reports referenced within this document, including the Marine Resources Assessment for the Mariana Islands. Furthermore, research cruises by NMFS and by academic institutions have received funding from the Navy. For instance, the Navy funded a marine mammal survey in the Mariana Islands to gather information to support an environmental study in that region given there had been no effort undertaken by NMFS. All of this research helps in understanding the marine environment and aids in determining if there are effects that result from Navy training in the Pacific.

The Navy has sponsored several workshops to evaluate the current state of knowledge and potential for future acoustic monitoring of marine mammals. The workshops brought together acoustic experts and marine biologists from the Navy and other research organizations to present data and information on current acoustic monitoring research efforts and to evaluate the potential for incorporating similar technology and methods on instrumented ranges. However, acoustic detection, identification, localization, and tracking of individual animals still requires a significant amount of research effort to be considered a reliable method for marine mammal monitoring. The Navy supports research efforts on acoustic monitoring and will continue to investigate the feasibility of passive acoustics as a potential mitigation and monitoring tool.

Overall, the Navy will continue to fund ongoing marine mammal research, and is planning to coordinate long term monitoring/studies of marine mammals on various established ranges and operating areas. The Navy will continue to research and contribute to university/external research to improve the state of the science regarding marine species biology and acoustic effects. These efforts include mitigation and monitoring programs; data sharing with NMFS and via the literature for research and development efforts; and future research as described previously.

5.2.3.3 MIRC Stranding Response Plan

Navy and NMFS are coordinating on whether a stranding response plan specific to Mariana Islands will be implemented and, if so, the contents of that plan. Upon completion of this coordination, appropriate information concerning the overall plan will be included in a draft plan and incorporated herein.

5.2.4 Alternative Mitigation Measures Considered but Eliminated

There is a distinction between effective and feasible monitoring procedures for data collection and measures employed to prevent impacts or otherwise serve as mitigation. The discussion below is in reference to those procedures meant to serve as mitigation measures.

- Using non-Navy personnel onboard Navy vessels to provide surveillance of ASW or other training events to augment Navy lookouts.
  - The protection of marine mammals is provided by a lookout sighting the mammal and prompting immediate action. The premise that Navy personnel cannot or will not do this is unsupportable. Navy lookouts are extensively trained in spotting items at or near the water surface and utilizing chain of command to initiate action. Navy lookouts utilize their skills more frequently than many third party trained marine mammal observers.
  - Use of Navy lookouts is the most effective means to ensure quick and effective communication within the command structure and facilitate implementation of mitigation measures if marine species are spotted. A critical skill set of effective Navy training is communication via the chain of command. Navy lookouts are trained to report swiftly and decisively using precise terminology to ensure that critical information is passed to the appropriate supervisory personnel.

  - Berthing space during Major Exercises, such as USWEX, is very limited. With exercise lengths of 1 to 3 weeks, and given limited at sea transfer, this option would mean that even if berthing is available, a biologist would have to depart with the ship as it leaves port and stay the duration of the exercise. Berthing on non-MFA sonar (i.e., carrier and amphibious assault ships) is more available, but distance from MFA sonar operations would not provide the desired mitigation given the distance to the MFA sources.
  - Lengthy and detailed procedures that would be required to facilitate the integration of information from non-Navy observers into the command structure.
  - Some training will span one or more 24-hour period with events underway continuously in that timeframe. It is not feasible to maintain non-Navy surveillance of these events given the number of non-Navy observers that would be required onboard for the minimally required, three 8-hour shifts.
  - Surface ships having MFA sonar may have limited berthing capacity. Exercise planning includes careful consideration of this berthing capacity in the placement of exercise controllers, data collection personnel, and Afloat Training Group personnel on ships involved in the training event. Inclusion of non-Navy observers onboard these ships would require that, in some cases, there would be no additional berthing space for essential Navy personnel required to fully evaluate and efficiently use the training opportunity to accomplish the training objectives.
  - Security clearance issues would have to be overcome to allow non-Navy observers onboard event participants.

- Visual surveillance as mitigation using non-Navy observers from non-military aircraft or vessels to survey before, during, and after training events to preclude sonar use in areas where marine mammals may be present.
  - These measures do not result in increased protection to marine species given that the size of the areas, the time it takes to survey, and the movement of marine species preclude real-time mitigation. Contiguous ASW events may cover many hundreds of square miles in a few hours given the participants are usually not visible to each other (separated by many tens of miles) and are constantly in motion. The number of civilian ships and/or aircraft required to monitor the area around these events would be considerable (in excess of a thousand of square miles). It is, thus, not feasible to survey or monitor the large areas in the time required to ensure these areas are devoid of marine mammals. In addition, marine mammals may move into or out of an area, if surveyed before an event, or an animal could move into an area after an event took place. Therefore, surveillance of the “exercise area” would be impracticable as a mitigation measure given that it will not result in precluding marine mammals from being in the “exercise area.”
  - Surveillance of an exercise area during an event raises safety issues with multiple, slow civilian aircraft operating in the same airspace as military aircraft engaged in combat training. In addition, most of the training events take place far from land, limiting both the time available for civilian aircraft to be in the training area and presenting a concern should aircraft mechanical problems arise.
  - Scheduling civilian vessel or aircraft surveillance to coincide with training events would negatively impact training effectiveness, if the exercise was contingent on completion of such surveillance. Exercise event timetables cannot be precisely fixed, but are instead based on the free-flow development of tactical situations to closely mimic real combat action. Waiting for civilian aircraft or vessels to complete surveys, refuel, or be on station would interrupt the

necessary spontaneity of the exercise and would negatively impact the effectiveness of the military readiness activity.

- The vast majority of MIRC training events involve a Navy aerial asset with crews specifically training to detect objects in the water. The capability of sighting from both surface and aerial platforms provides excellent survey capabilities using Navy training assets participating in the event.

- Avoidance of marine mammal habitats is not possible given that the full habitat requirements the marine mammals in the Mariana Islands are unknown. Accordingly, there is no information available on possible alternative exercise locations or environmental factors that would otherwise be less important to marine mammals in the Mariana Islands. In addition, these exercise locations were very carefully chosen by exercise planners based on training requirements and the ability of ships, aircraft, and submarines to operate safely. Moving the exercise events to alternative locations would impact the effectiveness of the training and has no known benefit (especially as there is no scientific data available to determine which specific areas should be avoided).
- Using active sonar with output levels as low as possible consistent with mission requirements and use of active sonar only when necessary.
  - Operators of sonar equipment are trained to be cognizant of the environmental variables affecting sound propagation. In this regard the sonar equipment power levels are always set consistent with mission requirements.
  - Active sonar is only used when required by the mission since it has the potential to alert opposing forces to the sonar platform's presence. Passive sonar and all other sensors are used in concert with active sonar to the maximum extent practical when available and when required by the mission.
- Suspending training at night, periods of low visibility and in high sea-states when marine mammals are not readily visible.
  - It is imperative that the Navy train to be able to operate at night, in periods of low visibility, and in high sea-states using the full potential of sonar as a sensor.
  - It would be extremely wasteful for Navy forces at sea to only operate in daylight hours or to wait for weather to clear before undertaking necessary training,
  - Navy vessels use radar and night vision goggles to detect any object, be it a marine mammal, a periscope of an adversary submarine, trash, debris, or another surface vessel
  - The Navy must train as expected to fight, and adopting this prohibition would eliminate this critical military readiness requirement.
- Reduce power in strong surface ducting conditions:
  - Strong surface ducts are conditions under which ASW training must occur to ensure sailors learn to identify the conditions, how they alter the abilities of MFA sonar systems, and how to deal with strong surface duct effects on MFA sonar systems. The complexity of ASW requires the most realistic training possible for the effectiveness and safety of the sailors. Reducing power in strong surface duct conditions would not provide this training realism because the unit would be operating differently than it would in a combat scenario, reducing training effectiveness and the crew's ability.
  - Additionally and most importantly, water conditions in the exercise areas on the time and distance scale necessary to implement this measure are not uniform and can change over the

period of a few hours as effects of environmental conditions such as wind, sunlight, cloud cover, and tide changes alter surface duct conditions. In fact, this mitigation measure cannot be accurately and uniformly employed given the many variations in water conditions across a typical exercise area that the determination of "strong surfacing ducting" is continually changing mitigation requirements and so cannot be accurately implemented.

- Surface ducting alone, does not increase the risk of MFA sonar impacts to marine mammals. While it is true that surface ducting causes sound to travel farther before losing intensity, simple spherical and cylindrical spreading losses result in a received level of no more than 175 dB at 1,000 meters, even in significant surface ducting conditions.
- There is no scientific evidence that this mitigation measure is effective or that it provides additional protection for marine mammals than the protection provided through "safety zones."

- Scaling down the exercise to meet core aims.
  - Training events are always constrained by the availability of funding, resources, personnel, and equipment with the result being they are always scaled down to meet only the core requirements.
- Limiting the active sonar use to a few specific locations.
  - Areas where events are scheduled to occur are carefully chosen to provide for the safety of events and to allow for the realistic tactical development of the training scenario. Otherwise limiting the training event to a few areas would adversely impact the effectiveness of the training.
  - Limiting the exercise areas would concentrate all sonar use, resulting in unnecessarily prolonged and intensive sound levels vice the more transient exposures predicted by the current planning that makes use of multiple exercise areas.
  - Major Exercises using integrated warfare components require large areas of the littorals and open ocean for realistic and safe training.
- Passive acoustic detection and location of marine mammals.
  - As noted in the preceding section, passive detection capabilities are used to the maximum extent practicable consistent with the mission requirements to alert training participants to the presence of marine mammals in an event location.
  - Implementation of this measure in and of itself is not more protective of the marine mammals because current technology does not allow for the real time detection and location of marine mammals.
  - Requires that marine mammals be vocalizing to be detected to be of any utility.
- Using ramp-up to attempt to clear an area prior to the conduct of training events.
  - Ramp-up procedures involving slowly increasing the sound in the water to necessary levels have been utilized in other non-DoD activities. Ramp-up procedures are not a viable alternative for training events, as the ramp-up would alert opponents to the participants' presence and not allow the Navy to train realistically, thus adversely impacting the effectiveness of the military readiness activity.
  - This would constitute additional unnecessary sound introduced into the marine environment, in and of itself constituting harassment.

- This measure does not account for the movement of the ASW participants over the period of time when ramp up would be implemented.
- The implicit assumption is that animals would have an avoidance response to the low power sonar and would move away from the sound and exercise area; however, there is no data to indicate this assumption is correct. The Navy is currently gathering data and assessing it regarding the potential usefulness of this procedure as a mitigation measure. However, given there is only limited data to indicate that this is even minimally effective and because ramp-up would have an impact on the effectiveness of the military readiness activity, it was eliminated from further consideration.

- Vessel speed reduction.
  - Vessels engaged in training use extreme caution and operate at a slow, safe speed consistent with mission and safety. Ships and submarines need to be able to react to changing tactical situations in training as they would in actual combat. Placing arbitrary speed restrictions would not allow them to properly react to these situations. Training differently than what would be needed in an actual combat scenario would decrease training effectiveness and reduce the crew's abilities.
- Use of new technology (e.g., unmanned reconnaissance aircraft, underwater gliders, instrumented ranges) to detect and avoid marine animals.
  - Although the Navy provides considerable funding into research on new technologies and devices (e.g., underwater gliders, radar, etc.) to date (2008), they are not developed to the point where they are effective or could be used as an actual mitigation tool.
- Use of larger shut-down zones.
  - The current power down and shut down zones are based on scientific investigations specific to MFA sonar for a representative group of marine mammals. It is also based on the source level, frequency, and sound propagation characteristics of MFA sonar. The zones are designed to preclude direct physiological effect from exposure to established marine mammal thresholds. Specifically, the current power-downs at 500 yards and 1,000 yards (457 and 914 meters [m]), as well as the 200 yards (183 m) shut-down safety zones were developed to minimize exposing marine mammals to sound levels that could cause temporary threshold shift (TTS) or permanent threshold shift (PTS). These sound level thresholds were established experimentally and are supported by the scientific community. Implementation of the safety zones discussed above were designed to prevent exposure to sound levels greater than that for onset TTS (195 dB re 1 μPa) for animals detected in the zone. Given that the distance to TTS from a single nominal sonar ping is less than 200 yards, there are additional protective buffers built into the safety zone with power-down of the sonar beginning when marine mammals are within 1,000 yards of the sonar (approximately five times the distance to TTS).
  - The safety zone the Navy has developed is also based on a lookout's ability to realistically maintain situational awareness over a large area of the ocean and the lookouts ability to detect marine mammals at that distance during most conditions at sea.
  - It should also be noted that lookouts are responsible for reporting all objects or anomalies sighted in the water regardless of the distance from the vessel. Any sighting is reported to the Officer of the Deck since any object, disturbance, or discoloration in the water may be indicative of a threat to the vessel and its crew or indicative of a marine species that may require some action be taken.

- Requirements to implement procedures when marine mammals are present well beyond 1,000 yards require that lookouts sight marine mammals at distances that, in reality, they cannot. These increased distances also greatly increase the area that must be monitored to implement these procedures. For instance, if a power down zone increases from 1,000 to 4,000 yards, the area that must be monitored increases sixteen fold.

- Avoid or limit the use of MFA sonar during ASW training events while conducting transits between islands
  - Conducting ASW training events while transiting between Mariana Islands does not present the same conditions as those that resulted in the Bahamas' stranding. Most importantly, there is no limited egress for marine mammals for events that occur between the Mariana Islands.
- Adopt mitigation measures of foreign nation navies
  - Some of these foreign nations' measures (such as predictive modeling) are not applicable to MIRC given the lack of information upon which to base any modeling. In a similar manner, avoidance of particular seasons or areas of known habitat are not transferable to the MIRC context.
  - Other nation's navies do not have the same critical mission to train in ASW as does the Navy. For example, other navies do not possess an integrated Strike Group. As a result, many foreign nations' measures would impact the effectiveness of ASW training to an unacceptable degree. The Navy's ASW training is built around the integrated warfare concept and is based on the Navy's sensor capabilities, the threats faced, the operating environment, and the overall mission.

5.3 TERRESTRIAL SPECIES AND HABITATS

The conservation measures that the Navy and Air Force have agreed to in prior consultations are still valid for MIRC training activities. These conservation measures are considered part of the No-Action Alternative for this EIS/OEIS.

5.3.1 Measures on Navy Controlled Lands

The abundance of biological resources within terrestrial habitats within the MIRC Study Area requires that basic land use constraints be established in potentially sensitive areas. These constraints are readily depicted on training overlays to assist military training planners, matching training activities to training sites, and to limit maneuver or certain training activities as necessary. Prior consultations referenced "No Training" and "No Wildlife Disturbance Areas" on various Navy properties (Waterfront Annex, Ordnance Annex, and MLA on Tinian, as well as targeting restrictions on FDM). Some of the training constraints on these properties were not designated based on habitat and species distributions. The only training restrictions that meet ecological criteria and do not conflict with baseline current training activities include: (1) the establishment of no training buffers around the three known swiftlet caves within the Ordnance Annex, and (2) the establishment of a no training buffer around Hagoi on Tinian within the MLA. Under the "No Training" land use constraint, entry into the area is prohibited, except for specifically authorized troop and vehicle movements on existing designated trails.

5.3.2 Measures on Andersen Air Force Base

The conservation measures developed by the Air Force were designed to compensate and minimize the potential impacts from implementation and operation of the ISR/Strike action to the Mariana fruit bat, Mariana crow, Micronesian kingfisher, and the Guam rail. The conservation measures correspond to recovery actions outlined in various USFWS recovery plans for these species. Overall goals of the conservation measures contribute to important habitat and species management objectives on Guam, and may be grouped into the following categories: (1) habitat improvement measures, (2) studies and research, (3) brown tree snake interdiction and control, and (4) adaptive management and avoidance/minimization measures. These measures are shown on Figure 3.11-9.

The following conditions are to be met relative to natural resources at both Northwest Field and Andersen South:

1. No vegetation clearing except:
    a. vegetation maintenance required to keep paved surfaces, landing zone, and the drop zone in a safe and useable condition and
    b. for bivouac purposes in the bivouac area.
2. Motorized vehicles shall be driven only on prepared surfaces and in the drop zone and landing zone as required to accomplish mission requirements.
3. Only rubber tired vehicles allowed.
4. No harassment or killing of wildlife allowed.
5. No digging allowed except in the Northwest Field bivouac area.

5.3.2.1 Measures Proposed to Reduce, Avoid, or Minimize Adverse Effects Associated with the Proposed Increase in Training Activities

In addition to the conservation measures and land-use constraints described in the preceding section, the Navy proposes the following measures to reduce, avoid, or minimize adverse effects to listed terrestrial species.

BTS Conservation Measures. The ongoing Section 7 ESA consultation discussions between the Navy and USFWS for activities associated with this EIS/OEIS will result in a Brown Treesnake procedures plan specific to MIRC activities. Both the Navy and USFWS agree that brown treesnake-specific conservation measures are necessary for the additional training levels. Increases in multiple large and small unit level training activities may increase the risk of unintentional transport and introduction of brown treesnake to CNMI terrestrial habitats and unintentional transport and introductions to sites outside of the MIRC, such as the Hawaiian Islands. Training activities that present potential brown treesnake introduction pathways include amphibious assaults and raids, MOUT, and other activities that require cargo or personnel to move through Guam to other MIRC training locations within the MIRC. The Navy, working in partnership with the USFWS, and USDA –Wildlife Services (USDA-WS) and Animal and Plant Health Inspection Service (APHIS) will decide how best to implement the Brown Treesnake Control Plan relevant to MIRC activities. The Navy strategy will involve three components: (1) avoidance, (2) minimization, and (3) offsetting measures. Specific aspects of these strategies are still in development and will be included in the USFWS Biological Opinion; however, the overall strategies are outlined below:

- *100% Interdiction:* The Navy is committed to implementing 100 percent inspection of all outgoing vessels and aircraft with dog detection teams, which could be supplemented by other pest control expertise (with appropriate USDA-Wildlife Service brown treesnake detection training and oversight) to meet 100 percent inspection goals for large scale training activities.
- *BTS Minimization Measures:* The Navy will support actions to assist with rapid response to brown treesnake sighting within the CNMI and locations outside of the MIRC, specifically Hawaii.

- *BTS Offsetting Measures:* The Navy will fund additional project within the BTS Control Plan.

- *BTS awareness training for all personnel involved in training activities.*

Ungulate Management Planning on Navy Lands. An ungulate management plan and an Environmental Assessment currently in development that will provide a long-term program and methods for a sustained reduction of ungulates on Navy lands (Brooke, 2007).

Rat eradication on FDM. The rodenticide diphacinone has recently been approved for field use by USEPA for rat eradications. Successful rat eradications on pacific islands have been accomplished on Mokapu (off Molokai), Campbell Island (New Zealand), and San Jorge (Solomon Islands), as well as successful application within portions of Hawaii Volcanoes National Park. Given the small size of FDM, island wide eradication is possible (NAVFACPAC, 2008a). This action will provide direct benefits to nesting seabirds (eggs and nesting substrate) and indirect benefits to Micronesian megapodes by increasing vegetation on certain portions of the island.

Quarterly seabird population monitoring at FDM. The Navy proposes to conduct quarterly surveys using the same protocols as the monthly monitoring surveys for seabirds and other resources at FDM (aerial surveys). NAVFACPAC biologists have over 10 years of monitoring data at FDM for seabird populations on FDM, which show no significant changes in the population indices. Therefore, the Navy concludes that quarterly monitoring of FDM seabird populations would be sufficient to meet monitoring goals at FDM.

Life History Studies of the Micronesian megapode. The Navy proposes to conduct a study on the Micronesian megapode life history on Tinian and Sarigan.

Fire management on Navy lands within the MIRC. The Navy is developing fire management protocols for training activities within the MIRC.

Maintain buffers around sensitive ecological features. The Navy will maintain already identified buffers around such features as Mariana swiftlet caves and wetland areas. The intent of the buffers is to protect ecological resources from potential impacts associated with training activities, while not interfering with facility operations.

5.4 CULTURAL RESOURCES

A MOA regarding the implementation of military training on Guam was signed and executed in 1999 (USCINCPAC REP GUAM/CNMI, 1999a). The 1999 restrictions on training exercises correspond to mapped constrained areas designated as NCRD. The northwest portion of Andersen AFB including Northwest Field is encompassed by a large NCRD zone. The MOA also stipulates an annual commemoration of the last World War II bombing mission that took off from Northwest Field; development of a long-term management plan for Northwest Field; and consultation with the Guam HPO to avoid historic properties during rapid runway repair training. As a result of this MOA, a permanent marker to the last mission of World War II has been established at Northwest Field.

A MOA regarding the RED HORSE Beddown Initiatives at Northwest Field, Andersen AFB was signed and executed in 2006 (USAF, 2006b). The MOA stipulated Historic American Building Survey/Historic American Engineering Record (HABS/HAER) documentation of the Northwest Field runway complex and previously existing facilities; and implementation of cultural resources inventory and evaluation investigations for areas scheduled for ground disturbing activities. As a result of this MOA, a runway repair location has been established at Northwest Field for the RED HORSE Beddown Initiatives.

An ICRMP was prepared in 2003 (USAF, 2003) for Andersen AFB to ensure that cultural resources are managed in a planned and coordinated manner. The ICRMP established SOPs for the review of work orders; inadvertent discovery of archaeological resources; inadvertent discovery of human remains; ground disturbing activity in archaeological sensitive areas; request for access by off-base personnel; requests to conduct archaeological studies; during emergency situations; in the event of natural disasters; for permits, leases, and contracts; for enforcement and monitoring; and installation restoration projects.

Based on current consultations with the Guam SHPO, CNMI HPO, ACHP, and the NPS, a new PA is currently being negotiated for all military training activities proposed under the Preferred Alternative and will include additional mitigation measures and procedures. The PA is scheduled for signature in July 2009 prior to the release of the FEIS and the signed PA will be incorporated into the FEIS.

5.4.1 Guam Commercial Harbor

Two areas within Outer Apra Harbor are designated as NT areas; seven additional areas within the harbor are designated as NCRD (USCINCPAC REP GUAM/CNMI, 1999a).

5.4.2 Apra Harbor Naval Complex (Main Base)

As a result of the 1999 MOA, one area in the Apra Harbor Naval Complex (Main Base) is designated as an NT area; four additional areas within the annex are designed as NCRD (USCINCPAC REP GUAM/CNMI, 1999a). The Navy, Air Force, and the Cultural Resources Partners (Advisory Council of Historic Preservation, Guam Historic Preservation Officer, and CNMI Historic Preservation Officer) are negotiating on a new Programmatic Agreement for all military training in the Marianas covered in this EIS/OEIS.

5.4.3 Tinian

A Programmatic Agreement (PA) regarding the implementation of military training on Tinian was signed and executed in 1999 (Commander in Chief, U.S. Pacific Command Representative Guam and the Commonwealth of the Northern Mariana Islands [USCINCPAC REP GUAM/CNMI], 1999b). Restrictions on training exercises correspond to mapped constrained areas designed as NT or NCRD. NT areas designate complete avoidance with no training exercises. NCRD areas indicate limited military training activities with no vehicular travel off-road, no pyrotechnic, no demolition, and no digging without prior written approval from the USCINCPAC REP. Beach access roads for ingress and egress by military and recreational vehicles are also clearly delineated on the constraints map, particularly in regard to Unai Chulu and Unai Dankulo. The PA also stipulates cultural resources monitoring of specific military training activities by qualified personnel. Three areas in the Military Lease Area (MLA) are designed as NT areas; nine large areas are designed as NCRD (USCINCPAC REP GUAM/CNMI, 1999b). The Navy, Air Force, and the Cultural Resources Partners (Advisory Council of Historic Preservation, Guam Historic Preservation Officer, and CNMI Historic Preservation Officer) are negotiating on a new Programmatic Agreement for all military training in the Marianas covered in this EIS/OEIS.

An Updated Cultural Resources Management Plan (UCRMP) was prepared in 2003 (Tomonari-Tuggle et al., 2003) for the MLA on Tinian to ensure that cultural resources are managed in a planned and coordinated manner. The UCRMP established standard operating procedures for new projects; inadvertent discovery of archaeological resources; inadvertent discovery of human remains; inadvertent disturbance to historic properties; during emergency situations; in the event of natural disasters; and for permits, leases, and contracts.

5.4.4 Andersen Air Force Base

In addition to the 1999 MOA regarding the implementation of training on Guam, a MOA regarding the Northwest Field Beddown Initiatives at Anderson AFB was signed and executed in 2006 (USAF, 2006b). The MOA stipulated Historic American Building Survey/Historic American Engineering Record (HABS/HAER) documentation of the Northwest Field runway complex and previously existing facilities; and implementation of cultural resources inventory and evaluation investigations for areas scheduled for ground disturbing activities. The Navy, Air Force, and the Cultural Resources Partners (Advisory Council of Historic Preservation, Guam Historic Preservation Officer, and CNMI Historic Preservation Officer) are negotiating on a new Programmatic Agreement for all military training in the Marianas covered in this EIS/OEIS.

5.5 LAND USE

Andersen Air Force Base. The future land use for Guam does not protect the off-base CZ and APZ areas of North field and the areas around Northwest Field from future encroachment. There are no restrictions on higher residential densities and various, more intense land uses or height restrictions. On the southwest end of the Northwest Field runway, lands have been rezoned allowing hotels and resorts in the CZ and APZ I. On the northeast end of the Northwest Field runway, the area was rezoned low intensity development. On both ends of the Northwest Field runway, there is a possibility of exposing a large number of people to the risk of an aircraft accident.

To minimize noise impacts to surrounding communities, the following mitigation measures are included in the plan and implemented:

- Restricted nighttime flying activities and flight tracks routed to avoid populated areas.
- Practice takeoffs/landings and instrument approaches, and base maintenance runup activities conducted during normal waking hours (scheduled between 0600 and 2200 pm) only.
- Only mission essential aircraft arrivals and departures, high priority missions allowed between 2200 and 0600.
- Whenever possible, traffic patterns would be located away from the populated areas, both on and off-base.

This page intentionally left blank.

CHAPTER 6 CUMULATIVE IMPACTS

6.1 PRINCIPLES OF CUMULATIVE IMPACTS ANALYSIS

The assessment of cumulative impacts (or cumulative effects)[1] was made using an ecosystem management approach and follows the objectives of the National Environmental Policy Act (NEPA) of 1969, Council on Environmental Quality (CEQ) regulations, and CEQ guidance. CEQ regulations (40 Code of Federal Regulations [CFR] Sections [§§] 1500-1508) provide the implementing procedures for NEPA. The regulations define cumulative effects as:

> "'. . . the impact on the environment which results from the incremental impact of the action when added to the other past, present, and reasonably foreseeable future actions regardless of what agency (Federal or non-Federal) or person undertakes such other actions. Cumulative impacts can result from individually minor but collectively significant actions taking place over a period of time." (40 CFR 1508.7).

CEQ provides guidance on cumulative impacts analysis in *Considering Cumulative Effects Under the National Environmental Policy Act* (CEQ, 1997). This guidance further identifies cumulative effects as those environmental effects resulting "from spatial and temporal crowding of environmental perturbations. The effects of human activities will accumulate when a second perturbation occurs at a site before the ecosystem can fully rebound from the effects of the first perturbation." Noting that environmental impacts result from a diversity of sources and processes, this CEQ guidance observes that "no universally accepted framework for cumulative effects analysis exists," while noting that certain general principles have gained acceptance. One such principle provides that "cumulative effects analysis should be conducted within the context of resource, ecosystem, and community thresholds – levels of stress beyond which the desired condition degrades." Thus, "each resource, ecosystem, and human community must be analyzed in terms of its ability to accommodate additional effects, based on its own time and space parameters." Therefore, cumulative effects analysis normally will encompass geographic boundaries beyond the immediate area of the Proposed Action, and a time frame including past actions and foreseeable future actions, in order to capture these additional effects. Bounding the cumulative effects analysis is a complex undertaking, appropriately limited by practical considerations. Thus, CEQ guidelines observe, "[i]t is not practical to analyze cumulative effects of an action on the universe; the list of environmental effects must focus on those that are truly meaningful."

6.1.1 Identifying Geographical Boundaries for Cumulative Impacts Analysis

Geographic boundaries for analyses of cumulative impacts in this EIS/OEIS vary for different resources and environmental media. For air quality, the potentially affected air quality regions are the appropriate boundaries for assessment of cumulative impacts from releases of pollutants into the atmosphere. For wide-ranging or migratory wildlife, specifically marine mammals and sea turtles, any impacts from the Proposed Action or Alternatives might combine with impacts from other sources within the range of the population. Therefore, identification of impacts elsewhere in the range of a potentially affected population is appropriate. For terrestrial biological resources, the Navy controlled and managed areas and locations in Table 2-2 and Figures 2-1 through 2-11 are the appropriate geographical area for assessing cumulative impacts. For all other ocean resources, the ocean ecosystem of the marine waters off Mariana Islands is the appropriate geographic area for analysis of cumulative impacts.

[1] CEQ Regulations provide that the terms "cumulative impacts" and "cumulative effects" are synonymous (40 CFR § 1508.8[b]); the terms are used interchangeably.

6.1.2 Past, Present, and Reasonably Foreseeable Future Actions

Identifiable present effects of past actions are analyzed, to the extent they may be additive to impacts of the Proposed Action. In general, the Navy need not list or analyze the effect of individual past actions; cumulative impacts analysis appropriately focuses on aggregate effects of past actions. Reasonably foreseeable future actions that may have impacts additive to the effects of the Proposed Action also are to be analyzed.

6.1.2.1 Other Projects and Activities Analyzed for Cumulative Impacts

Various types of reasonably foreseeable future actions that are relevant to the Proposed Action have the potential to affect the resources identified in Chapter 3. Table 6-1 is an overview of these actions that emphasizes components of the activities that are relevant to the effects analysis in Chapter 3. Additionally, projects in the planning phase were considered, including reasonably foreseeable (rather than speculative) actions that have the potential to interact with the proposed Navy action. Geographic distribution, intensity, duration, and the historical effects of similar activities are considered when determining whether a particular activity may contribute cumulatively and significantly to the effect identified in Chapter 3.

Table 6-1: Reasonably Foreseeable Future Actions Relevant to the Proposed Action

Project	Project Sponsor	Project Description	Projected Completion Date	Relevance to MIRC EIS	Terrestrial or Marine
Guam - GovGuam					
Commercial Port Improvements East of Hotel Wharf	Port Authority of Guam (PAG)	Construct new wharf to accommodate deep-draft container vessels and cruise ships. Dredging and filling of GovGuam submerged lands required.	2021-2025	Additive	Marine
New Landfill Dandan	Department of Public Works (DPW)	Development of a municipal solid waste landfill facility. Project involves construction and operation of integrated solid waste facility and transfer stations. Will provide for waste management through diversion, recycling, composting, and processing.	Design complete	Beneficial	Terrestrial
Pagan Mining	Guam Government Administration	The government administration is negotiating with JG Sablan Rock Quarry, Inc. for a settlement that would allow mining to resume at Pagan. The volcanic ash on Pagan has a pozzolan substance which is an ingredient in the production of hydraulic cement.	To be determined	Additive	Terrestrial
Guam International Airport Improvements	Guam International Airport Authority (GIAA)	Various upgrades to airport property, main terminal, industrial park, airfield, and south ramp.	To be determined	Additive	Terrestrial
Reforestation of Masso Reservoir	GovGuam and U.S. Navy	The reforestation plan was developed as a mitigation project for coral reef loss in Apra Harbor. 12 acres of native vegetation and a 30-acre security fence will surround the reservoir.	Completed within 3 years	Additive	Terrestrial

Table 6-1: Reasonably Foreseeable Future Actions Relevant to the Proposed Action (Continued)

Project	Project Sponsor	Project Description	Projected Completion Date	Relevance to MIRC EIS	Terrestrial or Marine
2030 Guam Transportation Plan	Department of Public Works (DPW)	The plan involves significant repairs and upgrades of Guam's transportation network. The project will be funded through grants from the U.S. Department of Transportation, Federal Highway Administration, and other funding sources.	The plan guides Federally funded transportation projects over the next 5 years	Additive	Terrestrial
Other Guam Projects					
Marianas Trench Marine National Monument	National Park Service	The Monument consists of approximately 71,897 square nautical miles (246,600 square kilometers) of submerged lands and waters of the Mariana Archipelago. The Monument includes the waters and submerged lands of the three northernmost Mariana Islands (the 'Islands Unit') and only the submerged lands of designated volcanic sites (the 'Volcanic Unit') and the Mariana Trench (the 'Trench Unit').	Established in January 2009 by Presidential Proclamation.	Additive	Marine
Draft Safe Harbor Agreement	U.S. Fish and Wildlife Service (USFWS)	Cocos Island Resort and the Guam Department of Agriculture have applied for an enhancement of survival permit and a proposed Safe Harbor Agreement for the benefit of the ko'ko'. Implementation of the proposed agreement would provide for voluntary habitat restoration, maintenance, and activities to enhance the habitat and recovery of the Guam rail on 83.1 acres of Cocos Island partly owned by Cocos Island Resort, and the Guam Department of Parks and Recreation.	The draft agreement and proposed permit was published in the *Federal Register* on January 10, 2008	Additive	Terrestrial
5-year review of species under the Federal Endangered Species Act (ESA)	USFWS	The Pacific Region of the USFWS is initiating 5-year reviews of 70 species protected under the Federal Endangered Species Act. One of the species under review is the Megapode, Micronesian (*Megapodius laperouse*) which is endangered with a current range of the Mariana Islands.	Public Comment ended June 30, 2008	Additive	Terrestrial
Designation of Ocean Dredge Material Disposal Site EIS	USEPA	USEPA environmental analysis for proposed designation of offshore disposal site for dredged materials.	Notice of Intent published December 2007	Additive	Marine
Residential Construction Tamuning (Near Nikko Hotel)	Non-Governmental Organization (NGO)	Construction of a 700-unit condominium facility. Subdivision on Ypao Road.	2010	Additive	Terrestrial

Table 6-1: Reasonably Foreseeable Future Actions Relevant to the Proposed Action (Continued)

Project	Project Sponsor	Project Description	Projected Completion Date	Relevance to MIRC EIS	Terrestrial or Marine
Residential Construction Yigo (Near AAFB Back Gate)	Non-Governmental Organization (NGO) Base Corp.	Construction of Paradise Estates residential homes, a 400-lot subdivision and Villa Pacita residential homes.	Currently under construction	Additive	Terrestrial
Residential Construction Machanao	Non-Governmental Organization (NGO) Core Tech	Construction of low-income rental subdivision named Ironwood Estates.	Currently under construction	Additive	Terrestrial
"Project Runway" Australia-Guam Submarine Cable	Non-Governmental Organization (NGO) PIPE Networks	Construction of a submarine cable link from Australia to Guam.	2008-2009	Additive	Marine
Hotel Construction Bayview 5 Luxury Project	Non-Governmental Organization (NGO)	Construction of 220-room 28-story hotel in Tumon Bay.	2010	Additive	Terrestrial Marine
Navy					
Guam and CNMI Military Relocation EIS/OEIS	Joint Guam Program Office (JGPO)	The JGPO is preparing an EIS/OEIS for relocation of Marines from Okinawa. Project notionally includes infrastructure construction and beddown of personnel, CVN Berthing and the Army's Ballistic Missile Defense System.	To be determined	Additive	Terrestrial Marine
Facility Construction AAFB	FACSFAC Range Control	Construction of a facility to serve as a Training Operations Center and CVW-5 liaison office.	To be determined	Additive	Terrestrial
Facility Construction Navy Base	Navy	Construction of surface, subsurface, and aerial target facility; underwater tracking range (portable acoustic range); and Theater Support Vessel facility.	To be determined	Additive	Terrestrial

Table 6-1: Reasonably Foreseeable Future Actions Relevant to the Proposed Action (Continued)

Project	Project Sponsor	Project Description	Projected Completion Date	Relevance to MIRC EIS	Terrestrial or Marine
Facility Construction Guam and CNMI Various Locations	Navy	Data backbone that includes microwave and data link backbone, electronic warfare portable staging site.	To be determined	Additive	Terrestrial
Infrastructure Construction and Environmental Analysis Orote Penninsula	Commander Navy Region Marianas	Analysis of a Proposed Action to construct 17 nonpropagation wall magazines for storage of 2M lb NEW C/D 1.1 on Orote Plateau. New construction will provide sufficient capacity for one full cargo ship and include security fencing, utility extensions, access road, and vegetation clearing.	To be determined	Additive	Terrestrial Marine
		Recent completion of environmental analysis for a Proposed Action to improve the Navy's power infrastructure by increasing the capability of the Orote Substation to increase backup generation capacity and replace 2 miles of overhead power lines under ground.	Finding of No Significant Impact (FONSI) completed		
		A project currently under construction to replace existing water lines with larger size lines, provide miscellaneous water mains and line connections, construct a concrete enclosure for the Fena Lake Pump Station, and install pressure reducing valves for waterlines feeding Sasa Valley, X-Ray Wharf, and Polaris Point.	2008		
		Analysis of a Proposed Action to construct the Kilo Wharf Extension and construction of associated facilities. Project requires construction of new facilities at Kilo Wharf to meet DoD technical design standards to ensure safe and efficient ordnance loading/offloading for the Auxiliary Dry Cargo/Ammunition Ship.	2010		
		Waterfront improvements to accommodate the new T-AKE supply ship and utility upgrades to meet wharf requirements. Includes construction dredging at the southern portion of Inner Apra Harbor to -35 feet.	2010		

Table 6-1: Reasonably Foreseeable Future Actions Relevant to the Proposed Action (Continued)

Project	Project Sponsor	Project Description	Projected Completion Date	Relevance to MIRC EIS	Terrestrial or Marine
Infrastructure Construction Navy Base	Commander Navy Region Marianas	Environmental analysis for a Proposed Action to construct new Bachelor Enlisted Quarters at Guam Naval Base for enlisted personnel. The project includes three- and four-story buildings with reinforced concrete walls, flooring, and foundation, containing 376 modules. The proposed site for the facility is a 2.6-acre site A contract was awarded for wastewater treatment plant repairs and upgrades. The project will replace one of the sewage lift stations and reinforce the protection from major storms.	2009 2010	Additive	Terrestrial
Infrastructure Construction Sumay Cove Polaris Point	Commander Navy Region Marianas	Pending environmental analysis for a Proposed Action to construct a new consolidated waterfront operations complex at Sumay Cove; project includes an equipment storage facility at Polaris Point and installation of two surface approach radar systems.	2010 pending site approval and environ analysis	Additive	Terrestrial Marine
Infrastructure Construction	Commander Navy Region Marianas	Pending environmental analysis of a Proposed Action to harden Navy's electrical distribution system by replacing the existing overhead primary and secondary electrical distribution with an underground installation for increased system reliability during frequent typhoons.	2010 pending site approval and environ analysis	Additive	Terrestrial
Infrastructure Construction Joint Region Headquarters and Operations Center	Commander Navy Region Marianas	Pending environmental analysis of a Proposed Action to renovate and adapt existing Buildings 200, 202, and 205 currently used as Department of Defense Education Activity high schools for joint use by Navy and JGPO.	2010 pending site approval and environ analysis	Additive	Terrestrial
Infrastructure Construction	Commander Navy Region Marianas	Pending site approval for a Proposed Action to construct a one-story torpedo exercise support facility.	2010 pending site approval	Additive	Terrestrial
Infrastructure Construction Consolidated Submarine Learning Center and Commander, Submarine Squadron Headquarters Facility	Commander Navy Region Marianas	Pending site approval for a Proposed Action to construct a new two-story consolidated Submarine Learning Center (SLC) and Commander, Submarine Squadron (CSS) Headquarters Facility. The SLC will house valuable equipment that will allow multiple undersea warfare training scenarios. The CSS facility will include administrative spaces, conference room, emergency control center, and classified material storage.	2010 pending site approval	Additive	Terrestrial

Table 6-1: Reasonably Foreseeable Future Actions Relevant to the Proposed Action (Continued)

Project	Project Sponsor	Project Description	Projected Completion Date	Relevance to MIRC EIS	Terrestrial or Marine
Air Force					
AAFB – Infrastructure Improvement Northwest Field	36WG of the Pacific Air Forces (PACAF)	Proposed Action to relocate a Rapid Engineer Deployable Heavy Operational Repair Squadron Engineer (RED HORSE) Squadron, the PACAF Commando Warrior training program, and a Combat Communication Squadron and its training program at the same location. The project includes beddown of an additional 400 personnel, utility and infrastructure improvements, and construction of field training areas, offices, classrooms, and warehouses to be based at Northwest Field, AAFB.	FONSI 2006 Construction pending 2006-2011	Additive	Terrestrial
AAFB – Beddown of Additional Missions and Personnel	36WG of the Pacific Air Forces (PACAF)	Proposed Action to base 3 unmanned aerial reconnaissance craft and 12 refueling aircraft at AAFB and accommodate 48 fighter and 6 bomber aircraft on a rotational basis. An additional 2,400 personnel would be based at AAFB.	Record of Decision (ROD) 2007 Pending Implementation 2007-2016	Additive	Terrestrial
AAFB – Instrastructure Improvement	36WG of the Pacific Air Forces (PACAF)	Multiple AAFB Infrastructure initiatives are programmed through 2012. These initiatives include (but are not limited to) munitions igloos, facilities, fencing, roads, relocation of the main gate, war readiness material storage facility, warehouse, and runway repair.	2012	Additive	Terrestrial
Tinian					
Casino and Condominium Resort Development	Bridge Investment Group	Development of a second casino for Tinian.	2008	Additive	Terrestrial
Relocation of Quarry	Marpo Valley Quarry (Government DPW)	Existing quarry operated by Power Builders International has to be relocated due to land lease to developers.	2008	Additive	Terrestrial
Relocation of Landfill	DPW	Relocation of current landfill to be co-located with Proposed Wastewater Treatment Plant.	To be determined Environmental analysis complete	Additive	Terrestrial

Table 6-1: Reasonably Foreseeable Future Actions Relevant to the Proposed Action (Continued)

Project	Project Sponsor	Project Description	Projected Completion Date	Relevance to MIRC EIS	Terrestrial or Marine
Proposed Wastewater Treatment Plant	Commonwealth Utilities Corporation	Proposed Tinian Wastewater Treatment Plant.	Environmental analysis in progress	Additive	Terrestrial
Harbor Rehabilitation Project	Commonwealth Ports Authority	Power Builders International is presently upgrading dock surfaces, bulkheads, and bollards.	Current construction	Additive	Terrestrial
Airport Infrastructure Improvements	CPA	Project and construction specifics to be determined.	Ongoing construction	Additive	Terrestrial

6.2 Cumulative Impacts Analysis

6.2.1 Air Quality

Activities affecting air quality in the region include, but are not limited to, mobile sources such as automobiles and aircraft, and stationary sources such as power generating stations, manufacturing operations, and other industries. Implementation of the No Action Alternative, Alternative 1, or Alternative 2 in conjunction with the cumulative actions listed in Table 6-1 would result in increases in air emissions within the MIRC Study Area; however, in general terms, the air quality of the MIRC is considered very good (designated in attainment of the National Ambient Air Quality Standard (NAAQS), except for sulfur oxides around the two power facilities on Guam) (40 CFR 81.353). The proposed project consists of continuing military training activities in the MIRC. The project does not include the construction of new stationary emission sources; however, it includes repair and maintenance of existing training facilities to accommodate increased training events. Guam has an approved State Implementation Plan (SIP) which was developed to allow the Territory to achieve attainment of the NAAQS for sulfur oxides in an area where the standard is exceeded (area where power production facilities [Tanguisson and Piti power plants] burning high sulfur content fuel oil are located). The CNMI is in attainment of the NAAQS for all criteria pollutants and therefore is not required to have a SIP. The MIRC Study Area for this EIS/OEIS is in attainment for all criteria pollutants. Included within this characterization of regional air quality are the existing aircraft, surface ship, small water craft, and weapon emissions. Naval activity would have no significant impact on air quality under the No Action Alternative, Alternative 1, or Alternative 2. Naval activity in non-territorial waters would not cause significant harm to air quality under the No Action Alternative, Alternative 1, or Alternative 2. The Proposed Action would not result in significant cumulative air quality impacts.

6.2.2 Cultural Resources

Implementation of the No Action Alternative, Alternative 1, or Alternative 2 in conjunction with the cumulative actions listed in Table 6-1 would not result in significant cumulative impacts on cultural resources. The types of impacts typically associated with the alternatives include disturbance of archaeological sites during ground disturbance (construction or troop/equipment movement) or the unanticipated discovery of archaeological materials. In accordance with Section 106 of the National Historic Preservation Act (36 CFR 800), cultural resources mitigation measures as described in the various sections of Chapter 3 would be implemented, including avoidance of resources (the preferred mitigation) and/or implementation of specific requirements already outlined in agency planning documents for the affected area (*e.g.*, Integrated Cultural Resource Management Plans [ICRMPs], Programmatic Agreements [PAs], Memorandums of Agreement [MOAs]). Given the rigorous review process required under Section 106 prior to activities taking place, the measures already in place within agency planning documents to mitigate potential effects, and the diverse range of locations where activities would occur (representing different cultural contexts and site types), the implementation of alternatives presented in this EIS/OEIS, either individually or as a whole, would not result in significant cumulative impacts.

Shipwrecks are vulnerable to the effects of time, tides, storm surges, and marine organisms, damage from boats, wakes, anchor drops, and looting. Over time, elements of the ship deteriorate, break apart, and are covered by sand and marine organisms. The same is true for archeological sites, for they are also vulnerable to development, looting, erosion, and natural processes. Once damaged or destroyed, they cannot be recreated. However, with preplanning and avoidance, implementation of Alternative 1 would have a negligible contribution to continuing cumulative impacts (*"no adverse affect"* under Section 106). Two additional projects are scheduled for construction and implementation in the MIRC: the Kilo Wharf Extension and the JGPO actions.

Kilo Wharf Extension. The Kilo Wharf Extension project consists of 400 feet of wharf construction at the Apra Harbor Naval Complex. No impacts to cultural resources were identified as a result of this project (DoN 2008) and the Guam State Historic Preservation Office concurred with this determination. The Kilo Wharf Extension project does not contribute to regional cumulative impacts to cultural resources. No cumulative adverse effects on National Register of Historic Places (NRHP)-eligible or listed cultural resources, including visual resources, would occur resulting from the Kilo Wharf Extension project.

Joint Guam Program Office (JGPO) Actions. The JGPO actions involve the relocation of Command, Air, Ground, and Logistics units (about 8,500 Marine Corps personnel and 9,000 dependents) from Okinawa, Japan to Guam, CVN Berthing and the Army's Ballistic Missile Defense System (DoN 2007). Cultural resources impacts from the JGPO actions are expected to be extensive; archaeological surveys and cultural resources surveys will be conducted on approximately 11,535 acres on Guam, Tinian, Saipan, Pagan Island and Sarigan Island (Carson and Tuggle 2007) to identify additional NRHP-eligible resources. Unavoidable adverse effects to cultural resources (archaeological, architectural, and traditional cultural resources) are likely to occur on several islands with the implementation of the JGPO actions. In addition, the loss of NRHP-listed archaeological resources would undermine the historic quality of the region. Impacts to cultural resources from the JGPO actions will be identified in a separate environmental document. No impacts to cultural resources will occur as a result of the No Action Alternative, Alternative 1, or Alternative 2 for the proposed MIRC project; therefore the No Action Alternative, Alternative 1, or Alternative 2 will not contribute to regional cumulative impacts created by the proposed JGPO actions.

Andersen Air Force Base. Andersen Air Force Base has completed Section 106 consultation with the Guam State Historic Preservation Officer (SHPO) for the repair of potholes at Northwest Field. The consultation has resulted in a recommendation that the project be conducted consistent with the Secretary of Interior's Standards. The potholes are the result of cumulative use of the field by heavy equipment.

6.2.3 Marine Biological Resources

6.2.3.1 Marine Plants and Invertebrates

Potential cumulative impacts on marine plants and invertebrates in the MIRC Study Area include releases of chemicals into the ocean, introduction of debris into the water column and onto the seafloor, and mortality and injury of marine organisms near the detonation or impact point of ordnance or explosives. The presence of persistent organic compounds such as DDT (dichlorodiphyenyltrichloroethane) and PCBs (polychlorinated biphenyls) are of particular concern. In light of these concerns, Navy activities would have small or negligible potential impacts. There would be no long-term changes to species abundance or diversity, no loss or degradation of sensitive habitats, and no effects to threatened and endangered species. None of the potential impacts would affect the sustainability of resources, the regional ecosystem, or the human community.

6.2.3.2 Fish

Potential cumulative impacts of Navy activities include release of chemicals into the ocean, introduction of debris into the water column and onto the seafloor, mortality and injury of marine organisms near the detonation or impact point of ordnance or explosives, and physical and acoustic impacts of vessel activity. The overall effect on fish stocks to commercial and recreational fishing in the MIRC Study Area would be negligible.

Due to the wide geographic separation of most of the operations, Navy activities would have small or negligible potential impact, and their potential impacts are not additive or synergistic. Relatively small numbers of fish would be killed by shock waves from mines, inert bombs, and intact missiles and targets hitting the water surface. These and several other types of activities common to many exercises or tests have less-than-significant effects on fish: aircraft, missile, and target overflights; releases of munitions constituents; falling debris and small arms rounds; entanglement in military-related debris; and chaff. There would be no long-term changes in species abundance or diversity, no loss or degradation of sensitive habitats, and no significant effects to threatened and endangered species. None of the potential impacts would affect Essential Fish Habitat (EFH), sustainability of resources, the regional ecosystem, or the human community.

6.2.3.3 Sea Turtles

Five sea turtle species are known to occur, or have the potential to occur, in the MIRC Study Area. Each of these species is globally distributed, and each is listed as threatened or endangered. Please refer to Section 3.8.2 for more complete information regarding the distribution and conservation status of these sea turtle species. Incidental takes in fishing operations, or bycatch, is one of the most serious threats to sea turtle populations. Sea turtles commonly ingest or become entangled in marine debris (*e.g.*, tar balls, plastic bags, plastic pellets, balloons, and ghost fishing gear) as they feed along oceanographic fronts, where debris and their natural food items converge. Marine pollution from coastal runoff, marina and dock construction, dredging, aquaculture, increased underwater noise, and boat traffic can degrade marine habitats used by sea turtles. Sea turtles swimming or feeding at or just beneath the surface of the water are vulnerable to boat and vessel strikes, which can result in serious propeller injuries and death.

Disease, specifically fibropapillomatosis (FP), is a threat to green turtles in some areas of the world. In addition, scientists have documented FP in populations of loggerhead, olive ridley, and flatback turtles. The effects of FP at the population level are not well understood. It is poorly understood how some sea turtles function within the marine ecosystem. Global warming could potentially have an extensive impact on all aspects of a turtle's life cycle, as well as impact the abundance and distribution of prey items. Loss or degradation of nesting habitat resulting from erosion control through beach nourishment and armoring, beachfront development, artificial lighting, nonnative vegetation, and sea level rise is a serious threat affecting nesting females and hatchlings (National Oceanic and Atmospheric Administration [NOAA] 2007).

Vessel movements have the potential to affect sea turtles by directly striking or disturbing individual animals. Repeated exposure to stressors, including human disturbance such as vessel disturbance and anthropogenic sound, can result in negative consequences to the health and viability of an individual or population.

Directed harvest for subsistence, commercial, or scientific research adds to mortalities of sea turtle species. Impacts from military training activities in the MIRC Study Area are not likely to cumulatively affect any of the species subject to direct harvest. Throughout their life cycles, sea turtles undergo complex seasonal movements. Sea turtle movement patterns are influenced by changes in ocean currents, turbidity, salinity, and food availability. In addition to these factors, the distribution of many sea turtle species is dependent upon and often restricted by water temperature (Epperly *et al.* 1995; Davenport 1997; Coles and Musick 2000).

Sea turtles can be found throughout the MIRC Study Area; temporary disturbance incidents associated with MIRC activities could result in an incremental contribution to cumulative impacts on sea turtles. However, the mitigation measures identified in Chapter 5 would minimize any potential adverse effects on sea turtles from explosives. Further, since it is not likely that sea turtles can hear Mid-Frequency Active/High-Frequency Active (MFA/HFA) sonar, the Navy believes that this activity would not constitute a significant contribution to cumulative effects on sea turtles from other sources of impact including anthropogenic sound. The impacts of the Proposed Action and Alternatives are not likely to affect the species' or stock's annual rates of recruitment or survival. Therefore, the incremental impacts of the Proposed Action, Alternative 1, or Alternative 2 would not present a significant contribution to the effects on sea turtles when added to effects on sea turtles from other past, present, and reasonably foreseeable future actions.

6.2.3.4 Marine Mammals

Marine mammal distribution within the MIRC Study Area and throughout the world is affected by demographic, evolutionary, ecological, habitat-related, and anthropogenic factors (Bjørge 2002; Bowen *et al.* 2002; Forcada 2002; Stevick *et al.* 2002). Movement of individuals is generally associated with feeding or breeding activity (Stevick *et al.* 2002). Some baleen whale species, such as the humpback whale, make extensive annual migrations in the northern hemisphere to low-latitude mating and calving grounds in the winter and to high-latitude feeding grounds in the summer (Corkeron and Connor 1999). Migrations likely occur during these seasons due to the presence of highly productive waters and associated cetacean prey species at high latitudes and of warm water temperatures at low latitudes (Corkeron and Connor 1999; Stern 2002). However, not all baleen whales migrate. Cetacean movements can also reflect the distribution and abundance of prey (Gaskin 1982; Payne *et al.* 1986; Kenney *et al.* 1996). Cetacean movements are linked to indirect indicators of prey, such as temperature variations, sea-surface chlorophyll concentrations, and bottom depth (Fiedler 2002).

Risks to marine mammals emanate primarily from ship strikes, exposure to chemical toxins or biotoxins, exposure to fishing equipment that may result in entanglements, and disruption or depletion of food sources from fishing pressure and other environmental factors. Potential cumulative impacts of Navy activities on marine mammals would result primarily from possible ship strikes and sonar use.

Stressors on marine mammals and marine mammal populations can include both natural and human-influenced causes listed below and described in the following sections:

Natural Stressors

- Disease
- Natural toxins
- Weather and climatic influences
- Navigation errors
- Social cohesion

Human-Influenced Stressors

- Fisheries interactions/bycatch
- Ship strikes
- Pollution and ingestion
- Noise
- Whale watching

6.2.3.5 Natural Stressors

Significant natural causes of mortality, die-offs, and stranding discussed below include disease and parasitism; marine neurotoxins from algae; navigation errors that lead to inadvertent stranding; and climatic influences that impact the distribution and abundance of potential food resources (*i.e.*, starvation). Stranding also is caused by predation by other species such as sharks (Cockcroft *et al*. 1989; Heithaus, 2001), killer whales (Constantine *et al*. 1998; Guinet *et al*. 2000; Pitman *et al*. 2001), and some species of pinniped (Hiruki *et al*. 1999; Robinson *et al*. 1999).

Disease. Like other mammals, marine mammals frequently suffer from a variety of diseases of viral, bacterial, and fungal origin (Visser et al. 1991; Dunn et al. 2001; Harwood 2002). Gulland and Hall (2005, 2007) provide a summary of individual and population effects of marine mammal diseases.

Marine Neurotoxins. Some single-celled marine algae common in coastal waters, such as dinoflagellates and diatoms, produce toxic compounds that can bioaccumulate in the flesh and organs of fish and invertebrates (Geraci et al. 1999; Harwood 2002). Marine mammals become exposed to these compounds when they eat prey contaminated by these naturally produced toxins (Van Dolah 2005).

Weather Events and Climate Influences. Severe storms, hurricanes, typhoons, and prolonged temperature extremes may lead to local marine mammal strandings (Geraci et al. 1999; Walsh et al. 2001). Seasonal oceanographic conditions in terms of weather, frontal systems, and local currents may also play a role in stranding (Walker et al. 2005).

The effect of large-scale climatic changes to the world's oceans and how these changes impact marine mammals and influence strandings are difficult to quantify, given the broad spatial and temporal scales involved, and the cryptic movement patterns of marine mammals (Moore 2005; Learmonth *et al*. 2006). The most immediate, although indirect, effect is decreased prey availability during unusual conditions.

This, in turn, results in increased search effort required by marine mammals (Crocker *et al*. 2006), potential starvation if not successful, and corresponding stranding due directly to starvation or succumbing to disease or predation while in a weakened, stressed state (Selzer and Payne 1988; Geraci *et al*. 1999; Moore 2005; Learmonth *et al*. 2006; Weise *et al*. 2006).

Navigational Error. *Geomagnetism.* Like some land animals and birds, marine mammals may be able to orient to the Earth's magnetic field as a navigational cue, and areas of local magnetic anomalies may influence strandings (Bauer et al., 1985; Klinowska 1985; Kirschvink et al. 1986; Klinowska 1986; Walker et al. 1992; Wartzok and Ketten 1999).

Echolocation Disruption in Shallow Water. Some researchers believe stranding may result from reductions in the effectiveness of echolocation in shallow water, especially in the pelagic species of odontocetes who may be less familiar with coastlines (Dudok van Heel 1966; Chambers and James 2005). For an odontocete, echoes from echolocation signals contain important information on the location and identity of underwater objects and the shoreline. The authors postulate that the gradual slope of a beach may present difficulties to the navigational systems of some cetaceans, since live strandings commonly occur along beaches with shallow, sandy gradients (Brabyn and McLean 1992; Mazzuca *et al*. 1999; Maldini *et al*. 2005; Walker *et al*. 2005). A factor contributing to echolocation interference in turbulent, shallow water is the presence of microbubbles from the interaction of wind, breaking waves, and currents. Additionally, ocean water near the shoreline can have an increased turbidity (*e.g*., floating sand or silt, particulate plant matter) due to the run-off of fresh water into the ocean, either from rainfall or from freshwater outflows (*e.g*., rivers and creeks). Collectively, these factors can reduce and scatter the sound energy in echolocation signals and reduce the perceptibility of returning echoes of interest.

Social Cohesion. Many pelagic species such as sperm whales, pilot whales, melon-head whales, and false killer whales, and some dolphins occur in large groups with strong social bonds between individuals. When one or more animals strand due to any number of causative events, then the entire pod may follow suit out of social cohesion (Geraci et al., 1999; Conner 2000; Perrin and Geraci, 2002; NMFS 2007).

6.2.3.6 Anthropogenic Stressors

During the past few decades there has been an increase in marine mammal mortalities associated with a variety of human activities (Geraci *et al*. 1999; NMFS 2007). These activities include fisheries interactions (bycatch and directed catch), pollution (marine debris, toxic compounds), habitat modification (degradation, prey reduction), ship strikes (Laist *et al*. 2001), and gunshots.

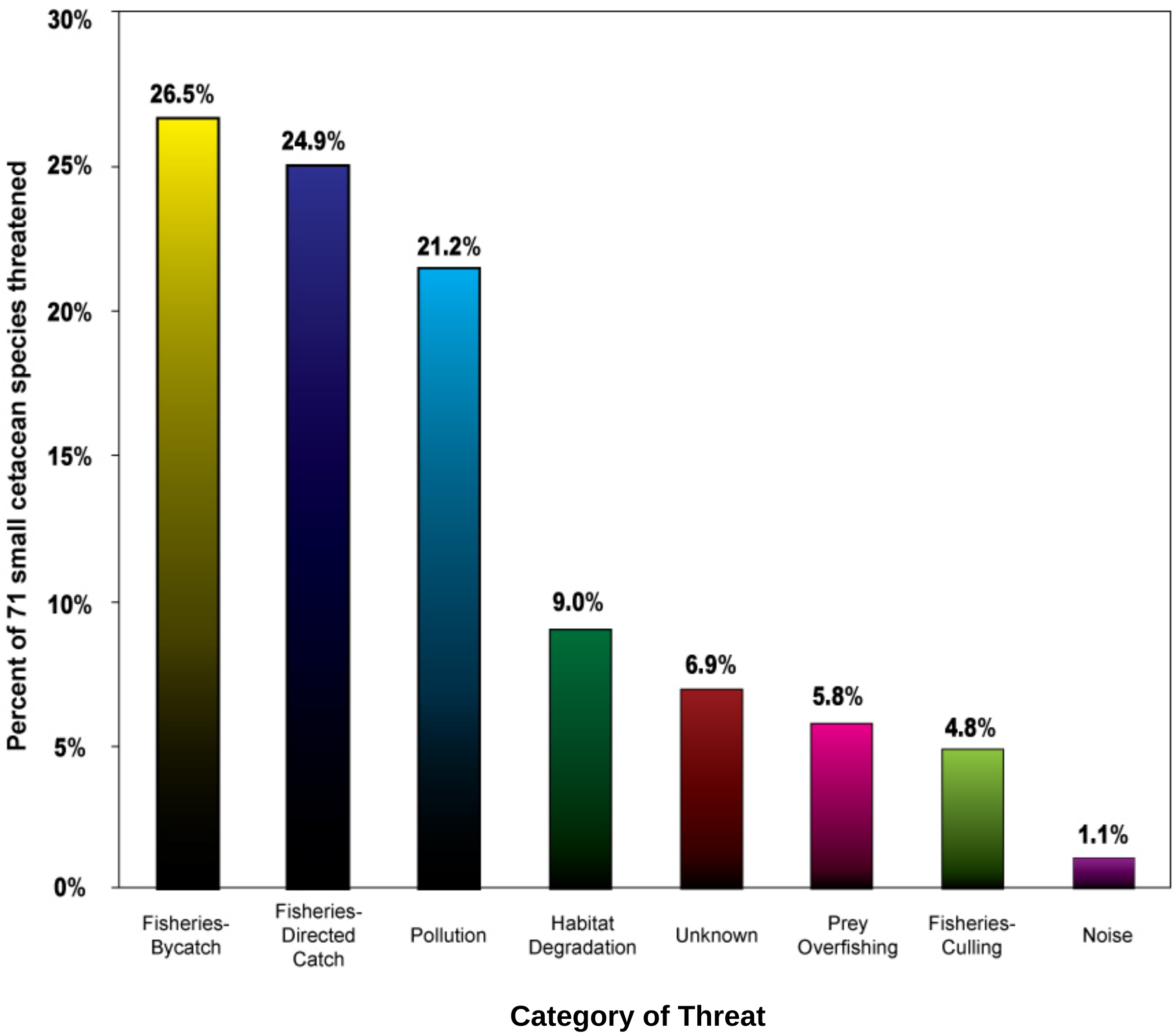


Figure 6-1: Human Threats to Worldwide Small Cetacean Populations

Source: Culik, 2002

Ship Strikes. Many of the migratory species of large whales examined in this EIS/OEIS could be at risk to ship strike from all sources during their migrations within the MIRC Study Area as well as their destinations outside of the Study Area. These species include humpback whales, fin whales, sperm whales, sei whales, Bryde's whales, and minke whales. Commercial shipping and commercial fishing could contribute to ship strike as part of cumulative effects. As noted in Jensen and Silber (2004), certain classes of vessels are likely overrepresented in the data, in particular Federal vessels including Navy and Coast Guard ships, which are required to report all strikes of marine mammals.

Factors that contribute to this include nonreporting by commercial vessels, failure to recognize ship-strikes by larger ships (*e.g.*, ≥40,000 tons), smaller Navy and Coast Guard ships, and greater numbers of dedicated observers/watch standers aboard Navy and Coast Guard ships which result in more and better reporting. In 2006 there were nine ship strikes by vessels engaged in whale watching according to the Pacific Islands Region Marine Mammal Response Network.

Navy vessel traffic is a small fraction (approximately 2 percent) of the overall U.S. commercial and fishing vessel traffic (Jensen and Silber 2003). While Navy vessel movements may contribute to the ship strike threat, given the lookout and mitigation measures adopted by the Navy, probability of vessel strikes is greatly reduced. Furthermore, actions to avoid close interaction of Navy ships and marine mammals and sea turtles, such as maneuvering to keep away from any observed marine mammal and sea turtle are part of existing at-sea protocols and standard operating procedures (see Chapter 5 for further explanation of Navy Standard Operating Procedures and Mitigation Measures). Navy ships have up to three or more dedicated and trained lookouts as well as two to three bridge watchstanders during at-sea movements who would be searching for any whales, sea turtles, or other obstacles on the water surface. Such lookouts are expected to further reduce the chances of a collision.

Note that the majority of ships participating in Navy Training exercises, such as Navy destroyers, have a number of advantages for avoiding ship strike as compared to most commercial merchant vessels.

- The Navy ships have their bridges positioned forward, offering good visibility ahead of the bow.
- Crew size is much larger than merchant ships
- During all Anti-Submarine Warfare (ASW) events, Mine Integrated Warfare (MIW) events, and some nearshore ship movements, there are lookouts posted scanning the ocean for anything detectible in the water; anything detected is reported to the Officer of the Deck.
- Navy lookouts receive extensive training, including Marine Species Awareness Training designed to provide marine species detection cues and information necessary to detect marine mammals and sea turtles.
- Navy ships are generally much more maneuverable than commercial merchant vessels.

The contribution to cumulative effects by military readiness activities within the MIRC Study Area with respect to ship strike are expected to be minimal given the relatively small percentage of ship traffic represented by Navy ships and the mitigation measures identified in Chapter 5.

Fisheries Interaction: Bycatch, Entanglement, and Directed Catch. The incidental catch of marine mammals in commercial fisheries is a significant threat to the survival and recovery of many populations of marine mammals (Geraci et al. 1999; Baird 2002; Culik 2002; Carretta et al. 2004; Geraci and Lounsbury 2005; National Marine Fisheries Service [NMFS] 2007). Interactions with fisheries and entanglement in discarded or lost gear continue to be a major factor in marine mammal deaths worldwide (Geraci et al. 1999; Nieri et al. 1999; Geraci and Lounsbury 2005; Read et al. 2006; Zeeber et al. 2006). For instance, baleen whales and pinnipeds have been found entangled in nets, ropes, monofilament line, and other fishing gear that has been discarded out at sea (Geraci et al. 1999; Campagna et al. 2007).

Bycatch. Bycatch is the catching of nontarget species within a given fishing operation and can include noncommercially used invertebrates, fish, sea turtles, birds, and marine mammals (National Research Council [NRC] 2006). Read *et al*. (2006) attempted to estimate the magnitude of marine mammal bycatch in U.S. and global fisheries. Within U.S. fisheries, between 1990 and 1999 the mean annual bycatch of marine mammals was 6,215 animals. Eighty-four percent of cetacean bycatch occurred in gill-net fisheries, with dolphins and porpoises constituting most of the cetacean bycatch (Read *et al*. 2006). Over the decade there was a 40 percent decline in marine mammal bycatch, primarily due to effective conservation measures that were implemented during this time period. With global marine mammal bycatch likely to be in the hundreds of thousands every year, bycatch in fisheries are the single greatest threat to many marine mammal populations around the world (Read *et al*. 2006).

Section 118 of the Marine Mammal Protection Act (MMPA) requires that the NMFS implement take reduction plans to reduce interactions between commercial fishing gear and marine mammals, as necessary. NMFS has also assessed the potential risk for marine mammal interactions in the United States and assigned each fishery to a Category (Category I, II, or III) depending on the likelihood of interactions with marine mammals in a particular fishery. Additional information on NMFS's efforts to implement the MMPA and minimize interactions with marine mammals and fisheries can be found on the official NOAA website, "Marine Mammal Protection Act (MMPA) of 1972 (NOAA 2008a).

Entanglement. Entangled marine mammals may die as a result of drowning, escape with pieces of gear still attached to their bodies, or manage to be set free either of their own accord or by fishermen. Many large whales carry off gear after becoming entangled (Read *et al*. 2006). When a marine mammal swims off with gear attached, the result can be fatal. The gear may become too cumbersome for the animal or it can be wrapped around a crucial body part and tighten over time. Stranded marine mammals frequently exhibit signs of previous fishery interaction, such as scarring or gear attached to their bodies. For stranded marine mammals, death is often attributed to such interactions (Baird and Gorgone, 2005). Because marine mammals that die due to fisheries interactions may not wash ashore and not all animals that do wash ashore exhibit clear signs of interactions, data probably underestimate fishery-related mortality and serious injury (NMFS 2005).

Directed Catch. Within the region of influence authorized whale kills from scientific research and subsistence harvest are not known to occur. Therefore, no cumulative effects are expected from military readiness activities within the MIRC Study Area with respect to authorized directed kills of marine mammals. Directed harvest of sea turtle nesting females and eggs on the beach and in the water is still widespread. Directed take is a major threat to hawksbills in the CNMI (NMFS 2008).

Ingestion of Plastic Objects and Other Marine Debris and Toxic Pollution Exposure. For many marine mammals, debris in the marine environment is a great hazard. Not only is debris a hazard because of possible entanglement, animals may mistake plastics and other debris for food (NMFS 2007g). Sperm whales have been known to ingest plastic debris, such as plastic bags (Evans et al. 2003; Whitehead 2003). While this has led to mortality, the scale on which this is affecting sperm whale populations is unknown, but Whitehead (2003) suspects it is not substantial at this time.

High concentrations of potentially toxic substances within marine mammals along with an increase in new diseases have been documented in recent years. Scientists have begun to consider the possibility of a link between pollutants and marine mammal mortality events. NMFS takes part in a marine mammal biomonitoring program not only to help assess the health and contaminant loads of marine mammals, but also to assist in determining anthropogenic impacts on marine mammals, marine food chains, and marine ecosystem health. Using strandings and bycatch animals, the program provides tissue/serum archiving, samples for analyses, disease monitoring and reporting, and additional response during disease investigations (NMFS 2007).

The impacts of these activities are difficult to measure. However, some researchers have correlated contaminant exposure with possible adverse health effects in marine mammals (Borell 1993; O'Shea and Brownelll 1994; O'Hara and Rice 1996; O'Hara *et al*. 1999).

The manmade chemical PCB, and the pesticide DDT are both considered persistent organic pollutants that are currently banned in the United States for their harmful effects in wildlife and humans (NMFS 2007c). Despite having been banned for decades, the levels of these compounds are still high in marine mammal tissue samples taken along U.S. coasts (Hickie *et al*. 2007; Krahn *et al*. 2007; NMFS 2007c). Both compounds are long-lasting, reside in marine mammal fat tissues (especially in the blubber), and can have toxic effects such as reproductive impairment and immunosuppression (NMFS 2007c).

In addition to direct effects, marine mammals are indirectly affected by habitat contamination that degrades prey species availability, or increases disease susceptibility (Geraci *et al*. 1999).

Navy vessel operation between ports and exercise locations has the potential to release small amounts of pollutant discharges into the water column. Navy vessels are not a typical source, however, of either pathogens or other contaminants with bioaccumulation potential such as pesticides and PCBs. Furthermore, any vessel discharges such as bilge water and deck runoff associated with the vessels would be in accordance with international and U.S. requirements for eliminating or minimizing discharges of oil, garbage, and other substances, and not likely to contribute significant changes to ocean water quality or to affect marine mammals.

Anthropogenic Sound. As one of the potential stressors to marine mammal populations, noise and acoustic influences may disrupt marine mammal communication, navigational ability, and social patterns, and may or may not influence stranding. Many marine mammals use sound to communicate, navigate, locate prey, and sense their environment. Both anthropogenic and natural sounds may interfere with these functions, although comprehension of the type and magnitude of any behavioral or physiological responses resulting from man-made sound, and how these responses may contribute to strandings, is rudimentary at best (NMFS 2007). Marine mammals may respond both behaviorally and physiologically to anthropogenic sound exposure, (e.g., Richardson et al. 1995; Finneran et al. 2000; Finneran et al. 2003; Finneran et al. 2005). However, the range and magnitude of the behavioral response of marine mammals to various sound sources is highly variable (Richardson et al. 1995) and appears to depend on the species involved, the experience of the animal with the sound source, the motivation of the animal (e.g., feeding, mating), and the context of the exposure.

Marine mammals are regularly exposed to several sources of natural and anthropogenic sounds. Anthropogenic noise that could affect ambient noise arises from the following general types of activities in and near the sea, any combination of which can contribute to the total noise at any one place and time. These noises include: transportation; dredging; construction; oil, gas, and mineral exploration in offshore areas; geophysical (seismic) surveys; sonar; explosions; and ocean research activities (Richardson *et al*. 1995). Commercial fishing vessels, cruise ships, transport boats, recreational boats, and aircraft, all contribute sound into the ocean (NRC 2003; 2006). Several investigators have argued that anthropogenic sources of noise have increased ambient noise levels in the ocean over the last 50 years (NRC 1994, 1996, 2000, 2003, 2005; Richardson *et al*. 1995; Jasny *et al*. 2005; McDonald *et al*. 2006). Much of this increase is due to increased shipping due to ships becoming more numerous and of larger tonnage (NRC 2003; McDonald *et al*., 2006). Andrew *et al*. (2002) compared ocean ambient sound from the 1960s with the 1990s for a receiver off the California coast. The data showed an increase in ambient noise of approximately 10 decibel (dB) in the frequency range of 20 to 80 Hertz (Hz) and 200 and 300 Hz, and about 3 dB at 100 Hz over a 33-year period.

Vessel Noise. Sound emitted from large vessels, particularly in the course of transit, is the principal source of noise in the ocean today, primarily due to the properties of sound emitted by civilian cargo vessels (Richardson *et al*. 1995; Arveson and Vendittis 2006). Ship propulsion and electricity generation engines, engine gearing, compressors, bilge and ballast pumps, as well as hydrodynamic flow surrounding a ship's hull and any hull protrusions, contribute to a large vessels' noise emissions in the marine environment. Prop-driven vessels also generate noise through cavitation, which accounts much of the noise emitted by a large vessel depending on its travel speed. Military vessels underway or involved in naval operations or exercises, also introduce anthropogenic noise into the marine environment. Noise emitted by large vessels can be characterized as low-frequency, continuous, and tonal. The sound pressure levels at the vessel will vary according to speed, burden, capacity, and length (Richardson *et al*. 1995; Arveson and Vendittis 2000). Vessels ranging from 135 to 337 meters generate peak source sound levels from 169 to 200 dB between 8 Hz and 430 Hz, although Arveson and Vendittis (2000) documented components of higher frequencies (10-30 kHz) as a function of newer merchant ship engines and faster transit speeds. Given the propagation of low-frequency sounds, a large vessel in this sound range can be heard 139 to 463 kilometers away (Ross 1976 in Polefka 2004). Navy vessels, however, have incorporated significant underwater ship quieting technology to reduce their acoustic signature (as compared to a similarly sized vessel) and thus reduce their vulnerability to detection by enemy passive acoustics (Southall 2006).

Vessel Mechanical Noise Sources. Mechanical noise on Navy ships, especially those engaged in ASW, is very quiet in comparison to civilian vessels of similar or larger size. Most Navy ships are built to reduce radiated noise so as to assist with the ship's passive ASW and make the ship harder for submarines to detect and classify them passively. This general feature is also enhanced by the use of additional quieting technologies (*i.e.*, gas turbine propulsion) as a means of limiting passive detection by opposing submarines.

Airborne Sound Source. Airborne sound from a low-flying helicopter or airplane may be heard by marine mammals and turtles while at the surface or underwater. Due to the transient nature of sounds from aircraft involved in at-sea exercises, such sounds would not likely cause physical effects but have the potential to affect behaviors. Responses by mammals and turtles could include hasty dives or turns, or decreased foraging (Soto *et al*., 2006). Whales may also slap the water with flukes or flippers, and swim away from the aircraft track.

Seismic and Explosive Sources. There are no reasonably foreseeable oil and gas exploration activities that would be occurring in the action area and thus no impacts from air guns or explosives to marine mammals are expected. Seismic exploration and nearshore/harbor construction employing explosives may contribute to anthropogenic noise within the action area. Temporary disturbance incidents associated with Navy activities, such as mine neutralization training, Gunnery Exercises, Sinking Exercises, or Service Weapons Tests could result in an incremental contribution to cumulative impacts on marine mammals. However, the mitigation measures identified in Chapter 5 should eliminate any potential adverse effects to marine mammals from explosives and no significant cumulative effects are anticipated.

Whale Watching. Whale and dolphin watching is specifically directed at following, closely observing these animals, or placing swimmers/divers to swim with dolphins and whales. Conversely Navy ships attempt to avoid marine mammals and sea turtles when they are observed or detected. While these commercial whale watching activities may have as yet undetected adverse impacts on marine mammals, including population level effects, military readiness activities within the MIRC Study Area are not expected to contribute to cumulative effects associated with whale watching in the MIRC Study Area.

Scientific Research. The effects of scientific research on marine mammals within the MIRC Study Area are not expected to be significant, and the contribution of military readiness activities within the MIRC Study Area to cumulative effects of scientific research are expected to be additive but minimal with implementation of the monitoring plan and mitigation measures presented in Chapter 5, and scientific research permit application evaluations conducted by NMFS.

Naval activity would have no significant impact on marine biological resources under the No Action Alternative, Alternative 1, or Alternative 2. Naval activity in non-territorial waters would not cause significant harm to marine biological resources under the No Action Alternative, Alternative 1, or Alternative 2. The Proposed Action would not result in significant cumulative marine biological resources impacts.

Navy LFA/MFA/HFA Sonar. Naval sonars are designed for three primary functions: submarine hunting, mine hunting, and shipping surveillance. There are two classes of sonar employed by the Navy: active sonar and passive sonar. Most active military sonars operate in a limited number of areas, and are most likely not a significant contributor to a comprehensive global ocean noise budget (International Council for the Exploration of the Sea 2005).

Increases in ambient noise levels might have the potential to mask an animal's ability to detect objects, such as fishing gear, and thus increase their susceptibility to bycatch. MFA sonar transmission, however, involves a very small portion of the frequency spectrum and falls between the central hearing range of the (generally) low-frequency specializing baleen whales and the (generally) high-frequency specializing odontocetes. In addition, the active portion of MFA/HFA sonar is intermittent, brief, and individual units engaged in the exercise are separated by large distances. As a result, MFA/HFA sonar use during Navy training activities will not contribute to an increase in baseline anthropogenic ambient noise levels to any significant degree. Additional discussion of MFA/HFA operational parameters is found in Section 3.7, Marine Mammals.

During training exercises, MFA/HFA sonar will add to regional sound levels, but the cumulative effects of potential short-term and intermittent acoustic exposure to marine mammals are not well known. The analysis of potential effects of MFA sonar from training events determined there is a potential for harassment of marine mammals. It is possible that harassment in any form may cause a stress response (Fair and Becker 2000). Cetaceans can exhibit some of the same stress symptoms as found in terrestrial mammals (Curry 1999). Disturbance from ship traffic, noise from ships and aircraft, and/or exposure to biotoxins and anthropogenic contaminants may stress animals, weakening their immune systems, and making them more vulnerable to parasites and diseases that normally would not be fatal. Any minimal incremental contribution to cumulative impacts on marine mammals from possible temporary harassment incidents associated with military readiness training within the MIRC Study Area would not likely be significant. The mitigation measures identified in Chapter 5 would be implemented to further minimize any potential adverse effects on marine mammals.

The Navy's most powerful surface ship sonar is the SQS-53, which has the nominal source level of 235 dB re 1 squared micropascal-second (μPa^2-s) at 1.09 yards (or 1 meter [m]). Generally (based on water conditions) a ping will lose approximately 60 dB after traveling 1,000 yards from the sonar dome, resulting in a received level of 175 dB at 1,000 yards from the sonar dome. The Navy's standard mitigation measures consider the area within 1,000 yards of the bow (the sonar dome) a Safety Zone. The resulting 175 dB sound level at 1,000 yards, where the Navy's mitigation Safety Zone begins, is for comparison, less than source level produced by the vocalization of many marine mammals and less than other sounds marine mammals may be exposed to, such as humpback fluke and flipper slaps at source levels of 183 to 192 dB (Richardson *et al*. 1995).

A nominal sonar ping is approximately 1 second in duration followed by a period of silence lasting 30 seconds or longer during which the MFA sonar system listens for a return reflection of that ping. An Undersea Warfare Exercise (USWEX) event can last for 72 to 96 hours, although the ASW portions of the exercise (modeled as three periods lasting approximately 16 hours each) are a subset of the total exercise timeframe. Within the ASW event where hull-mounted MFA sonar is used, the sonar system produces sound in the water only a small fraction of the time ASW is being conducted or, as in the preceding example, 2 seconds of sound every minute. When compared against naturally occurring and other man-made sources of noise in the oceans, the sonar pings during ASW events are only a brief and intermittent portion of the total acoustic noise.

The Navy's standard mitigation measures are designed to prevent direct injury to marine mammals as a result of the sonar's acoustic energy. The Navy currently employs the mitigation measures described in

Chapter 5. These are designed to prevent direct injury to marine mammals as a result of the sonar's acoustic energy. If any marine mammal is sighted within 1,000 yards of the bow, the sonar power is reduced by 75 percent (6 dB). The average level (195 dB) at which the onset of measurable physiological change to hearing (technically referred to as "temporary threshold shift [TTS]") could be determined occurs approximately 200 yards from a sonar dome transmitting a 1-second, 235 dB ping. The Safety Zone distance of 1,000 yards is more than four times the average distance at which the onset of a measurable and temporary physiological change occurs, and yet a significant power reduction is mandated if a marine mammal comes within this range. Additional protective measures, as detailed in Chapter 5, are in place to lessen the potential for there to be cumulative impacts or synergistic effect from the use of sonar during training exercises.

As discussed previously, because MFA/HFA sonar transmissions are brief and intermittent, cumulative impacts from ship strikes due to masking from MFA/HFA sonar signals are not a reasonably foreseeable significant adverse impact on marine animals

Cumulative Impacts and Synergistic Effects of LFA/MFA/HFA. MFA/HFA sonar make use of distinct and narrow fractions of the mid-frequency and high-frequency sound spectrum as noted previously. Other Navy systems (*i.e.*, fathometers) are specifically designed to avoid use of these same frequencies, which would otherwise interfere with the MFA/HFA sonar. These HFA sonar systems generally employ weaker power levels at higher frequencies which both result rapid attenuation of the sound levels. There should, therefore, be no cumulative impacts from multiple systems using the same frequency. For the same reason, there should be no synergistic effects from the MFA/HFA systems in use during Navy training. Because of major differences in signal characteristics between Low-Frequency Active (LFA) sonar, MFA/HFA sonar, and seismic air guns, there is negligible chance of producing a "synergistic" sound field. It is also unlikely that LFA sources, if operated in proximity to each other would produce a sound field so complex that marine animals would not be able to escape. The potential for sound waves from multiple sources and a marine mammal would converge at the same time to cause harm to the mammal is so unlikely that it is statistically insignificant.

The potential simultaneous use of both LFA sonar and MFA/HFA sonar systems in the MIRC would involve transmission in portions of both the low, mid-, and high-frequency sound spectrums. This raises a question regarding the potential for masking from the simultaneous use of these systems. There are, however, large differences between LFA and MFA/HFA sonar systems' signal characteristics given the time of transmission, depth, vertical steering angle, waveform, wavetrain, pulse length, pulse repetition rate, bandwidth, and duty cycle. The portion of the low frequency spectrum that LFA can affect is both small and short in duration. As described previously, MFA sonar transmissions are very brief, in a narrow frequency band, and typically on the order of a 1-second ping with 30 seconds between pings. Similarly, the HFA sources used are lower in power and generally at a single distinct frequency. Therefore, transmissions of LFA and MFA/HFA sonar, if overlapping in time, would do so only temporarily and would each be in narrow, non-overlapping and distinct frequency bands. They would, therefore, not be additive in a masking sense, even if they did overlap in time (they would mask different signals), though in the rare instances where there were overlapping signals from LFA and MFA/HFA sonar they could affect a broader portion of the broadband signals. However, due to the differences in the operational characteristics, especially signal duration, any cumulative masking effects from the simultaneous use of LFA and MFA/HFA systems are expected to be negligible and extremely unlikely.

Given the information provided in the Final Supplemental Environmental Impact Statement (SEIS) for Surveillance Towed Array Sensor System Low Frequency Active (SURTASS LFA) sonar, the potential for cumulative impacts and synergistic effects from the operations of up to four SURTASS LFA sonars was considered to be small and has been addressed by limitations proposed for employment of the system (*i.e.*, geographical restrictions and monitoring mitigation). Even if considered in combination with other underwater sounds, such as commercial shipping, other operational, research, and exploration activities (*e.g*., acoustic thermometry, hydrocarbon exploration and production), recreational water activities, naturally-occurring sounds (*e.g*., storms, lightning strikes, subsea earthquakes, underwater volcanoes, whale vocalizations, etc.) and mid-frequency active/high-frequency active (MFA/HFA) sonar, the proposed four SURTASS LFA sonar systems would not add appreciably to the underwater sounds to which fish, sea turtle and marine mammal stocks would be exposed. Moreover, SURTASS LFA sonar will cause no lethal takes of marine mammals (DoN, 2007). Therefore, cumulative impacts and synergistic effects of the operation of SURTASS LFA sonar systems in conjunction with the Proposed Action and Alternatives, in particular MFA/HFA, are not reasonably foreseeable.

Impacts from military readiness activities associated with the MIRC Study Area, including the use of MFA/HFA sonar, are not likely to affect the identified species or stock of marine mammals through effects on annual rates of recruitment or survival. Therefore, the incremental impacts from these activities would not represent a significant contribution to the cumulative effects on marine mammals or sea turtles when added to other past, present, and reasonably foreseeable future actions.

Potential harassment from SURTASS LFA sonar has been evaluated for the MIRC area in the 2007 SURTASS LFA Supplemental EIS (Department of the Navy [DoN] 2007a) and for synergistic affects of use of the systems for training. The potential cumulative impact issue associated with SURTASS LFA sonar operations is the addition of underwater sound to oceanic ambient noise levels and its use during the operation of MFA/HFA sonar in the MIRC area. While the operation of LFA and MFA/HFA sonar together in the MIRC area has the potential to expose marine mammals to these sources, there should not be any cumulative or synergistic effects given the differences in the systems frequencies as detailed below.

Anthropogenic sources of ambient noise that are most likely to contribute to increases in ambient noise levels are commercial shipping, offshore oil and gas exploration and drilling, and naval and other use of sonar (International Council for the Exploration of the Sea 2005). Increases in ambient noise levels have the potential to cause masking, and decrease in distances that underwater sound can be detected by marine animals. These effects have the potential to cause a long-term decrease in a marine mammal’s efficiency at foraging, navigating, or communicating (International Council for the Exploration of the Sea 2005). NRC (2003) discussed acoustically induced stress in marine mammals. National Research Council stated that sounds resulting from one-time exposure are less likely to have population-level effects than sounds that animals are exposed to repeatedly over extended periods of time.

Broadband, continuous low-frequency shipping noise is more likely to affect marine mammals than narrowband, low duty cycle SURTASS LFA sonar or the brief and intermittent signals from MFA/HFA sources. SURTASS LFA sonar bandwidth is limited (approximately 30 Hz), the average maximum pulse length is 60 seconds, signals do not remain at a single frequency for more than 10 seconds, and during an operation the system is off nominally 90 to 92.5 percent of the time. Most mysticete vocalizations are in the low frequency band below 1 kHz. No direct auditory measurements have been made for any mysticete, but it is generally believed that their frequency band of best hearing is below 1,000 Hz, where their calls have the greatest energy (Clark 1990; Edds-Walton 2000; Ketten 2000). However, with the nominal duty cycle of 7.5 to 10 percent, masking would be temporary. For these reasons, any masking effects from SURTASS LFA sonar are expected to be negligible and extremely unlikely.

Odontocetes have a broad acoustic range and hearing thresholds measure between 400 Hz and 100 kHz (Richardson, *et al*. 1995a; Finneran *et al*. 2002). It is believed that odontocetes communicate above 1,000 Hz and echolocate above 20 kHz (Würsig and Richardson 2002). While the upward spread of masking is known to exist, the phenomenon has a limited range in frequency. Yost (2000) showed that magnitude of the masking effect decreases as the difference between signal and masking frequency increase; *i.e.*, the masking effect is lower at three times the frequency of the masker than at two times the frequency. Gorga *et al*. (2002) demonstrated that for a 1.2-kHz masking signal, the upward spread of masking was extinguished at frequencies of 6 kHz and higher. Therefore, while the phenomenon of upward spread of masking does exist, it is unlikely that LFA would have any significant effect on the hearing of higher frequency animals. Gorga *et al*. (2002) also demonstrated that the upward spread of masking is a function of the received level of the masking signal. Therefore, a large increase in the masked bandwidth due to upward masking would only occur at high received levels of the LFA signal.

In a recent analysis for the Policy on Sound and Marine Mammals: An International Workshop sponsored by the Marine Mammal Commission (United States) and the Joint Nature Conservation Committee (United Kingdom) in 2004, Dr. John Hildebrand provided a comparison of anthropogenic underwater sound sources by their annual energy output. On an annual basis, four SURTASS LFA systems are estimated to have a total energy output of 6.8 x 10^{11} Joules/yr. Seismic air gun arrays were two orders of magnitude greater with an estimated annual output of 3.9 x 10^{13} Joules/year. MFA and super tankers were both greater at 8.5 x 10 and 3.7 x 10 Joules/year, respectively (Hildebrand 2004). Hildebrand concluded that increases in anthropogenic sources most likely to contribute to increased noise in order of importance are commercial shipping, offshore oil and gas exploration and drilling, and naval and other uses of sonar. The use of SURTASS LFA sonar is not scheduled to increase past the originally analyzed four systems during the next 5-year regulation under the MMPA. The percentage of the total anthropogenic acoustic energy budget added by each LFA source is actually closer to 0.5 percent per system (or less), when other man-made sources are considered (Hildebrand 2004). When combined with the naturally occurring and other manmade sources of noise in the oceans, the intermittent LFA signals barely contribute a measurable portion of the total acoustic energy.

In a recently released report entitled *Ad-Hoc Group on the Impact of Sonar on Cetaceans*, the International Council for the Exploration of the Sea (International Council for the Exploration of the Sea 2005) concluded that shipping accounts for more than 75 percent of all human sound in the sea, and sonar amounts to no more than 10 percent or so. It further stated that sonar (noise budget) would probably never exceed 10 percent, but that sonar deployment seems likely to increase in the future. Therefore, the SURTASS LFA Final SEIS, dated April 2007, concluded that because LFA transmissions would not significantly increase anthropogenic oceanic noise, cumulative impacts and synergistic effects from the proposed four SURTASS LFA sonar systems for masking would not be a reasonably foreseeable significant adverse impact on marine animals.

Synergistic Effects. The potential for synergistic effects of the operation of SURTASS LFA sonar with overlapping sound fields from other anthropogenic sound sources was initially analyzed based on two LFA sources (DoN 2007). In order for the sound fields to converge, the multiple sources would have to transmit exactly in phase (at the same time), requiring similar signal characteristics, such as time of transmissions, depth, vertical steering angle, waveform, wavetrain, pulse length, pulse repetition rate, and duty cycle. In the very unlikely event that this ever occurred, the analysis demonstrated that the "synergistic" sound field generated would be 75 percent or less of the value obtained by adding the results. Therefore, adding the results conservatively bounds the potential effects of employing multiple LFA sources. In the areas where marine mammals would potentially be affected by significant behavioral changes, they would be far enough away that they would discern each LFA sonar as an individual source. Standard operational employment of two SURTASS LFA sonars calls for the vessels to be nominally at least 185 km (100 nm) apart (DoN 2007). Moreover, LFA sources would not normally operate in proximity to each other and would be unlikely to transmit in phase as noted above. Based on this and the coastal standoff restriction, it is unlikely that LFA sources, under any circumstances, could produce a sound field so complex that marine animals would not know how to escape it if they desired to do so.

Because of the potential for seismic surveys to interfere with the reception of passive signals and return echoes, SURTASS LFA sonar operations are not expected to be close enough to these activities to have any synergistic effects. Because of the differences between the LFA coherent signal and seismic air gun impulsive “shots,” there is little chance of producing a “synergistic” sound field. Marine animals would perceive these two sources of underwater sound differently and any addition of received signals would be insignificant. This situation would present itself only rarely, as LFA testing and training operations have not been, and are not expected to be conducted in proximity to any seismic survey activity.

If SURTASS LFA sonar operations were to occur concurrent with other military (including MFA/HFA sonars) and commercial sonar systems, synergistic effects are not probable because of differences between these systems (DoN 2007). For the sound fields to converge, the multiple sources would have to transmit exactly in phase (at the same time), requiring similar signal characteristics, such as time of transmissions, depth, frequency, bandwidth, vertical steering angle, waveform, wavetrain, pulse length, pulse repetition rate, and duty cycle. The potential for this occurring is negligible.

Another area for potential cumulative effects would be those associated with marine mammal populations. To evaluate the effects of MIRC area sonar operations, it is necessary to place it in perspective with other anthropogenic impacts on marine resources.

Bycatch. Increases in ambient noise levels have the potential to mask an animal’s ability to detect objects, such as fishing gear, thus increasing their susceptibility to becoming bycatch. Because LFA/MFA/HFA transmissions are intermittent and would not significantly increase anthropogenic oceanic noise, cumulative impacts and synergistic effects from masking by MIRC activities signals are not a reasonably foreseeable significant adverse impact on marine animals.

Ship Strikes. Increases in ambient noise levels have the potential to mask an animal’s ability to detect approaching vessels, thus increasing their susceptibility to ship strikes. Because LFA/MFA/HFA transmissions are intermittent and will not significantly increase anthropogenic oceanic noise, cumulative impacts and synergistic effects from ship strikes due to masking are not a reasonably foreseeable significant adverse impact on marine animals from MIRC activities.

6.2.4 Onshore Biological Resources

Implementation of the No Action Alternative, Alternative 1, or Alternative 2 in conjunction with the cumulative actions listed in Table 6-1 could affect terrestrial biological resources within the MIRC Study Area. Several events contribute cumulatively to habitat degradation, including disturbance to soils and vegetation, spread of invasive non-native species, erosion and sedimentation, and impacts on native plant species. Although individual impacts may be less than significant, collectively they have the potential to be significant over time and space. Some potential effects of invasive species are difficult to foresee (such as leading to a change in fire frequency or intensity); however, it is clear that the potential for damage associated with introduction or spread of invasive plant species is high and increases over time with repeated training missions, especially exercises that cover a very large area, because of the difficulty in effectively monitoring for invasive establishment and achieving timely control. The Navy is addressing these effects with several strategies including (1) implementation of Integrated Natural Resources Management Plans (INRMPs), (2) continued development and implementation of measures to prevent the establishment of invasive plant species by minimizing the potential for introductions of seed or other plant parts (propagules) of exotic species, and (3) finding and eliminating incipient populations before they are able to spread. Key measures include:

- Minimizing the amount of seed or propagules of nonnative plant species introduced to the islands through continued efforts to remove seed and soil from all vehicles (including contractor vehicles) coming to the island by pressure washing at the ports of debarkation, and stepped up efforts to ensure that imported construction materials such as sand, gravel, aggregate, or road base material are weed free.
- Regular monitoring and treatment to detect and eliminate establishing exotic species, focusing on areas where equipment and construction materials come ashore and areas within which there is movement of equipment and personnel and soil disturbance which favor the spread and establishment of invasive species (*e.g.*, along roadsides, and disturbed areas).
- Effective measures to foster the reestablishment of native vegetation in areas where nonnative vegetation is present.
- Prohibiting living plant materials to be brought to the islands from the mainland (in order to avoid introduction of inappropriate genetic strains of native plants or exotic species, including weeds, insects, and invertebrates).

Although there are impacts associated with the implementation of the No Action Alternative, Alternative 1, or Alternative 2 on terrestrial biology within the MIRC Study Area; these impacts would be mitigated to less than significant level. Any construction project or training event would be required to be in compliance with the established INRMP and USFWS Biological Opinions. In addition, any project proposed within the MIRC Study Area affecting threatened or endangered species would have included ESA Section 7 consultation addressing direct, indirect, and cumulative impacts.

6.2.4.1 Geology, Soils, and Bathymetry Environment

Implementation of the No Action Alternative, Alternative 1, or Alternative 2 in conjunction with the cumulative actions listed in Table 6-1 would not result in significant impacts on geology and soils within the MIRC Study Area. The impacts on geology are minor and mostly consist of limited temporal and spatial disturbances to underwater sediments or localized soil disturbance in previously disturbed areas on the islands. Erosion is a naturally recurring issue, but it is not heavily exacerbated by military activities. While construction type projects in the region may have localized erosion, overall cumulative effects would be negligible since Best Management Practices for soil disturbing activities are typically implemented during any construction activity.

6.2.4.2 Hazardous Materials and Hazardous Waste

Some materials expended during training activities would be left in place. The expended materials are unlikely to result either in any significant environmental impacts to the sea floor or in a significant degradation of marine water quality. Over a period of years, these materials would degrade, corrode, and become incorporated into the sediments. There are no significant environmental impacts associated with hazardous materials and hazardous waste and there are no anticipated impacts to listed species and critical habitats.

Two additional projects are scheduled for construction and implementation in the MIRC: the Kilo Wharf Extension and the Guam and CNMI Military Relocation.

Kilo Wharf Extension. The Kilo Wharf Extension project does not contribute to regional cumulative impacts of hazardous materials and wastes.

Guam and CNMI Military Relocation EIS/OEIS. The Guam and CNMI Military Relocation EIS/OEIS will address impacts and issues for hazardous materials and wastes. For this reason, impacts of hazardous materials and wastes from the JGPO actions will be identified in a separate environmental document. The Proposed Actions in the MIRC EIS/OEIS would not result in significant cumulative hazardous materials or hazardous waste impacts.

6.2.4.3 Land Use

There are no NEPA or Executive Order (EO) 12114 effects on land use. There are no Navy activities proposed that will be incompatible with current land use plans and policies, there are no anticipated changes to current land use, and no incompatibility exists with adjacent land use. Naval activity would have no significant impact on land use activities under the No Action Alternative, Alternative 1, or Alternative 2. Naval activity in non-territorial waters would not cause significant harm to land use activities under the No Action Alternative, Alternative 1, or Alternative 2. The Proposed Action would not result in significant cumulative land use impacts.

6.2.4.4 Health and Safety

Public health and safety impacts are considered significant if the general public is substantially endangered as a result of military training activities on the ranges. Several factors were considered in evaluating the effects of the Navy's activities on public health and safety. These factors include proximity to the public, access control, scheduling, public notification of events, frequency of events, duration of events, range safety procedures, operational control of training events, and safety history.

No unavoidable significant environmental effects would be expected because the MIRC activities would continue to be accomplished in accordance with directives that are developed to ensure public health and safety. The Proposed Action would not result in significant cumulative public health and safety impacts.

6.2.4.5 Noise

Implementation of the No Action Alternative, Alternative 1, or Alternative 2 in conjunction with the cumulative actions listed in Table 6-1 would not incrementally affect noise within the MIRC Study Area. Noise levels are inherently localized because sound levels decrease relatively quickly with increasing distance from the source. Cumulative impacts would occur when multiple projects affect the same geographic areas simultaneously or when sequential projects extend the duration of noise impacts on a given area over a longer period of time. The increased level of training proposed under Alternatives 1 or 2 would increase noise levels; however, noise levels from training would be intermittent and similar to other noise levels already experienced in the MIRC Study Area. In addition, spatial separation among the cumulative projects listed in Table 6-1 would minimize or preclude cumulative noise impacts within the MIRC Study Area.

6.2.4.6 Socioeconomics

Implementation of the No Action Alternative, Alternative 1, or Alternative 2 in conjunction with the cumulative actions listed in Table 6-1 would not result in significant socioeconomic impacts within the region of influence. Implementation of the No Action Alternative, Alternative 1, or Alternative 2 would not produce any significant regional employment, income, housing, or infrastructure impacts. Effects on commercial and recreational fishermen, divers, and boaters would be short term in nature and produce some temporary access limitations. Some offshore events, especially if coincident with peak fishing locations and periods, could cause temporary displacement and potential economic loss to individual fishermen. However, most offshore events are of short duration and have a small operational footprint. Effects on fishermen are mitigated by public notification of scheduled activities. In selected instances where safety requires exclusive use of a specific area, commercial fishing vessels, commercial vessels, or private vessels may be asked to relocate to a safer nearby area for the duration of the exercise. These measures should not significantly impact any individual fisherman, overall commercial revenue, or public recreational opportunity in the open ocean area. Implementation of the No Action Alternative, Alternative 1, or Alternative 2 would not affect minority or low-income populations disproportionately, nor would children be exposed to increased noise levels or safety risks because events mainly occur at sea or in areas already designated for military activities.

6.2.4.7 Water Resources

Implementation of the No Action Alternative, Alternative 1, or Alternative 2 in conjunction with the identified cumulative actions listed in Table 6-1 would not result in significant impacts on water quality within the MIRC Study Area. For offshore training, the Navy would comply with the *Oil and Hazardous Substance Release and Contingency Plan* (40 CFR 300) developed for Navy activities within the MIRC Study Area. Water quality impacts associated with implementation of the No Action Alternative, Alternative 1, or Alternative 2 are transitory in nature and would not reach a level of significance even in conjunction with the impacts of the other actions considered in a regional context.

CHAPTER 7 REFERENCES

The following references are subdivided by their corresponding chapter/section where they are cited.

Chapter 1 References: Purpose and Need for Proposed Action

There are no references in this section.

Chapter 2 References: Description of Proposed Action and Alternatives

U.S. Air Force. (2000). *Environmental Assessment, Andersen Air Force Base Cargo Parachute Drop Zone*. Pacific Air Forces: 36th Air Base Wing.

U.S. Air Force. (2006). *Establishment and Operation of an Intelligence, Surveillance and Reconnaissance Strike, Andersen Air Force Base, Environmental Impact Statement*.

U.S. Air Force. (2006). *Environmental Assessment Beddown of Training and Support Initiatives at Northwest Field Andersen Air Force Base, Guam*. Prepared for Pacific Air Forces: Hickam AFB, HI.

U.S. Department of Defense. (1999). *Final Environmental Impact Statement – Military Training in the Marianas*. Prepared for Department of Defense: U.S. Pacific Command, Belt Collins, Hawaii.

U.S. Department of Defense. (2000). *COMNAVMARIANAS Instruction 3500.4, Marianas Training Handbook*. PACOM.

U.S. Department of the Navy. (1998). *Marianas Training Plan for DoD Facilities and Activities.*

U.S. Department of the Navy. (2002). *Overseas Environmental Assessment Notification for Air/Surface International Warning Areas*.

U.S. Department of the Navy. (2003). *Environmental Assessment for MOUT Training at Andersen South, Guam.* U.S. Marine Corps and Naval Facilities Engineering Command: Pacific Division.

U.S. Department of the Navy. (2005). *Standard Operating Procedures and Regulations for Restricted Area 7201 and Farallon de Medinilla (FDM) Laser Bombing Range*. COMNAVMARIANASINST 3502.1.

U.S. Department of the Navy. (2005). *Marine Resources Assessment for the Marianas Operating Area.* Final Report. Prepared for Department of the Navy: Commander, U.S. Pacific Fleet.

U.S. Department of the Navy. (2006). *Mariana Islands Range Complex Management Plan*. Volume II, Prepared for Commander, U.S. Pacific Fleet: Pearl Harbor, HI. SRS-Parsons JV. October 2007.

U.S. Department of the Navy. (2007). *Final Programmatic Overseas Environmental Assessment/Overseas Environmental Assessment, Exercise Valiant Shield*. Prepared for Commander, U.S. Pacific Fleet: Pearl Harbor, HI.

U.S. Department of the Navy. (2007). *Kilo Wharf Final Environmental Impact Statement.* Kilo Wharf FEIS Extension (MILCON P-502) FEIS at Apra Harbor Naval Complex: Guam, Mariana Islands.

Chapter 3: Affected Environment and Environmental Consequences

Section 3.1 References: Geology, Soils, and Bathymetry

Carruth, R.L. (2003). *Ground-Water Resources of Saipan, Commonwealth of the Northern Mariana Islands*. U.S. Geological Survey Water-Resources Investigations Report 03-4178: 3 Plates. Retrieved from the U.S. Geological Survey Web site: http://pubs.usgs.gov/wri/wri034178/htdocs/wrir03-4178.html

Guam Environmental Protection Agency. (2008). Radon information retrieved from the GEPA website http://www.guamepa.govguam.net/

Kolinski, Steven P. (2001). *Sea Turtles and their Marine Habitats at Tinian and Aguijan, with Projections on Resident Turtle Demographics in the Southern Arc of the Commonwealth to the Northern Mariana Islands.* Southwest Fisheries Science Center Administrative Report H-01-06C.

National Oceanic Atmopheric Administration. (2008). [Map]. Mariana Islands bathymetry map retrieved April 22, 2008 from the National Oceanic and Atmospheric Administration (NOAA) website http://oceanexplorer.noaa.gov/explorations/03fire/background/plan/marianas_220.jpg

Oceandots. (2008). Retrieved April 30, 2008, from http://www.oceandots.com/pacific/mariana/medinilla.htm

Paulay, Gustav. 2003). *Marine biodiversity of Guam and the Marianas: overview*. Micronesica 35 - 36: 3 - 25.

Smithsonian Institution. (2008). *Global Volcanism Program*. Information on Esmerelda Volcano from the Smithsonian National Museum of Natural History, Worldwide Holocene Volcano and Eruption Information retrieved April 22, 2008 from http://www.volcano.si.edu/world/volcano.cfm?vnum=0804-21=

University of Hawaii. (2008). Mariana Islands bathymetry information from the University of Hawaii at Manoa School of Ocean and Earth Science and Technology retrieved April 22, 2008 from http://www.soest.hawaii.edu/expeditions/mariana/index.html

University of Maine. (2008). [Map]. Map of Pacific Plate from the University of Maine Department of Earth Sciences retrieved April 23, 2008 from http://www.geology.um.maine.edu/geodynamics/analogwebsite/UndergradProjects2005/MKF_ERS416_2005/Graphics/realworld2.jpg

University of North Dakota. (2008). Volcano World website information on Ruby Seamount Retrieved April 22, 2008 from http://volcano.und.edu/vwdocs/current_volcs/mariana/mariana.html

University of Texas at Austin. (2008). [Map]. Perry-Castaneda Library Map Collection retrieved from http://images.google.com/imgres?imgurl=http://www.lib.utexas.edu/maps/australia/tinian_soil_1988.jpg&imgrefurl=http://www.lib.utexas.edu/maps/northern_mariana_islands.html&h=2822&w=1108&sz=288&hl=en&start=1&um=1&tbnid=rCWbPYgSy5h1kM:&tbnh=150&tbnw=59&prev=/images%3Fq%3DSoil%2Bmap%2BTinian%26um%3D1%26hl%3Den%26sa%3DN

U.S. Air Force. (1993). *Draft Environmental Impact Statement for Proposed Facilities Development and Relocation of Navy Activities to the Territory of Guam from the Republic of the Philippines*. U.S. Navy Pacific Division: Naval Facilities Engineering Command.

U.S. Air Force. (2004). *Final Environmental Assessment, Proposed Construction of Army and Air Force Exchange Service New Shoppette*. Andersen Air Force Base, Guam.

U.S. Air Force. (2006). *Final Environmental Impact Statement, Establishment and Operation of an Intelligence, Surveillance, and Reconnaissance, and Strike Capability*. Volumes I and II. Andersen Air Force Base, Guam.

U.S. Department of the Navy. (1999). *Final Environmental Impact Statement, Military Training in the Marianas.* Volumes I and II. PACOM.

U.S. Department of the Navy. (2000). *COMNAVMARIANAS Instruction 3500.4. Marianas Training Handbook*. PACOM.

U.S. Department of the Navy. (2001). *Final Integrated Natural Resources Management Plan for Navy Lands, Guam.* Plan Duration 18 November 2001 to 17 November 2006. COMNAVMARIANAS.

U.S. Department of the Navy. (2003). *Integrated Natural Resources Management Plan. Farallon De Medinilla and Tinian Military Lease Areas. Commonwealth of the Northern Mariana Islands.* Plan Duration FY 03 – 12. COMNAVMARIANAS.

U.S. Department of the Navy. (2005). *Marine Resources Assessment for the Marianas Operating Area.* Final Report. Prepared for Department of the Navy: Commander, U.S. Pacific Fleet.

U.S. Department of the Navy. (2007). *Draft Programmatic Overseas Environmental Assessment/Overseas Environmental Assessment, Exercise Valiant Shield.*

U.S. Environmental Protection Agency. (2006). *Amendment to Tier 2 Vehicle Emission Standards and Gasoline Sulfur Requirements: Partial Exemption for U.S. Pacific Island Territories*. Federal Register: December 28, 2006 (Volume 71, Number 249).

U.S. Geological Survey. (2008). Earthquake information retrieved April 22, 2008 from the U.S. Geological Survey Earthquakes Hazards Program website http://earthquake.usgs.gov/eqcenter/recenteqsww/Quakes/us2007hvbq.php

Section 3.2 References: Hazardous Materials and Hazardous Waste

Brinkley, S.R., & Wilson, E.B. (1943). *Calculations of detonation pressures for several explosives*. OSRD 1231.

Cook, D.S., & Spillman, E. (2000). Military training ranges as a source of environmental contamination. *Federal Facilities Environmental Journal*. Summer 27-37, 2000.

Jane's Ammunition Handbook. (2005). 5-inch 54-calibre naval gun ammunition.

Jane's Air-Launched Weapons. (2006). Mk 80 Series General Purpose Bombs (Mk 81, 82, 83, 84 and BLU-110/111/117).

John, H. (1941). British Report RC-166 and British Report RC-212.

John, H. (1943). British Report RC-383.

Renner, R.H. & Short, J.M. (1980). *Chemical Products of Underwater Explosions*, Naval Surface Weapons Center: Dahlgren, VA., NSWC/WOL TR 78-87.

U.S. Air Force. (1994). *United States Air Force Instruction 32-7042, Solid and Hazardous Waste Compliance.*

U.S. Air Force. (1997). *Environmental effects of self-protection chaff and flares.* Headquarters Air Combat Command: Langley Air Force Base, VA. NTIS PB98-110620.

U.S. Air Force. (2004). *United States Air Force Instruction (AFI) 32-7086, Hazardous Materials Management.*

U.S. Army Corps of Engineers. (2003). *Estimates for Explosives Residue from the Detonation of Army Munitions.*

U.S. Army Corps of Engineers. (2007). *Explosives Residues Resulting from the Detonation of Common Military Munitions, 2002-2006.*

U.S. Department of the Navy. (1996a). *Draft Environmental Assessment of the Use of Selected Navy Test Sites for Development Tests and Fleet Training Exercises of the MK-46 and MK-50 Torpedoes.* Program Executive Office Undersea Warfare: Program Manager for Undersea Weapons. CONFIDENTIAL.

U.S. Department of the Navy. (1996b). *Environmental Assessment of the Use of Selected Navy Test Sites for Development Tests and Fleet Training Exercises of the MK 48 Torpedoes*. Program Executive Office Undersea Warfare: Program Manager for Undersea Weapons. CONFIDENTIAL.

U.S. Department of the Navy. (1999). *Final Environmental Impact Statement, Military Training in the Marianas.* Volumes I and II. COMNAVMARIANAS.

U.S. Department of the Navy. (2000). *COMNAVMARIANAS Instruction 3500.4, Marianas Training Handbook*. COMNAVMARIANAS.

U.S. Department of the Navy. (2007). *OPNAVINST 5090.1C – Navy Environmental and Natural Resources Program Manual*.

U.S. Department of the Navy. (2008). *Final Range Condition Assessment, Mariana Land-Based Operational Range Complex, Decision Point 1 Recommendations Report, Guam and Commonwealth Northern Mariana Islands.* Prepared by Department of the Navy: Commander, Naval Facilities Engineering Command Pacific, Pearl Harbor, Hawaii. Contract Number N62742-02-D-1800, CTO 0010.

U.S. Environmental Protection Agency. (2006). *Method 8330, Appendix A: Collecting and Processing of Representative Samples for Energetic Residues in Solid Matrices from Military Training Ranges.*

Section 3.3 References: Water Quality

Burr, Susan E., Rudolph, Robert W., Kusler, Jon A., Guinther, Eric B., & Groom, Ivan. (2005). Commonwealth of the Northern Mariana Islands (CNMI) wetlands report. *State of the wetlands and recommendations or new wetlands policy*. AECOS, Inc. prepared for the CNMI Coastal Resources Management Office and the CNMI Wetlands Task Force.

Carruth, R.L. (2003). *Ground-Water Resources of Saipan, Commonwealth of the Northern Mariana Islands*. U.S. Geological Survey Water: Resources Investigations Report 03-4178, 3 Plates Retrieved from http://pubs.usgs.gov/wri/wri034178/htdocs/wrir03-4178.html

Ek, H., G. Dave, E. Nilsson, J. Sturve, & G. Birgersson. (2006). Fate and Effects of 2,4,6-Trinitrotoluene (TNT) from dumped ammunition in a field study with fish and invertebrates. *Archives of Environmental Contamination and Chemistry*, 51:244-252.

Lotufo, G.R. & M.J. Ludy. (2005). Comparative toxicokinetics of explosive compounds in Sheepshead minnows. *Archieves of Environmental Contamination and Toxicology* 49:206-214.

Naval Institute Guide to Ships and Aircraft of the U.S. Fleet. (2001). Navy EOD 60R-2-2-13; Table 1. Technical Description Documents SW515-A5-MMM-010, SW515-AG-OMP-010, SW516-AA-010.

Rosen, G. & G.R. Lotufo. (2005). Toxicity and fate of two munitions constituents in spiked sediment exposures with the marine amphipod *Eohaustorius estuarius*. *Environmental Toxicology and Chemistry* 24 (11): 2887-2897.

Rosen, G. & G.R. Lotufo. (2007a). Toxicity of explosive compounds to the marine mussel *Mytilus galloprovincialis*, in aqueous exposures. *Ecotoxicology and Environmental Safety*, 68(2): 228-236.

Rosen, G. & G.R. Lotufo. (2007b). Bioaccumulation of explosive compounds to the marine mussel *Mytilus galloprovincialis,* in aqueous exposures. *Ecotoxicology and Environmental Safety*, 68(2): 237-245.

U.S. Air Force. (1997). *Environmental Effects of Self-Protection Chaff and Flares*. Prepared for Headquarters Air Combat Command: Langley Air Force Base, Virginia.

U.S. Air Force. (2000). *Environmental Assessment, Andersen Air Force Base Cargo Parachute Drop Zone*. Pacific Air Forces: 36th Air Base Wing.

U.S. Air Force. (2006). *Final Environmental Impact Statement. Establishment and Operation of an Intelligence, Surveillance, and Reconnaissance, and Strike Capability*. Andersen Air Force Base, Guam. Volumes I and II.

U.S. Army Corps of Engineers. (2003). *Estimates for Explosives Residue from the Detonation of Army Munitions* retrieved from Web Site http://www.crrel.usace.army.mil/techpub/CRREL_Reports/reports/TR03-15.pdf

U.S. Department of the Navy. (No Date). *San Clemente Island Ordnance Database, Preliminary Environmental Impact Statement.*

U.S. Department of the Navy. (1996a). *Draft Environmental Assessment of the Use of Selected Navy Test Sites for Development Tests and Fleet Training Exercises of the MK-46 and MK-50 Torpedoes.* Program Executive Office Undersea Warfare: Program Manager for Undersea Weapons. CONFIDENTIAL.

U.S. Department of the Navy. (1996b). *Environmental Assessment of the Use of Selected Navy Test Sites for Development Tests and Fleet Training Exercises of the MK 48 Torpedoes*. Program Executive Office Undersea Warfare: Program Manager for Undersea Weapons. CONFIDENTIAL.

U.S. Department of the Navy. (1999). *Final Environmental Impact Statement, Military Training in the Marianas.* Volumes I and II.

U.S. Department of the Navy. (2000). *COMNAVMARIANAS Instruction 3500.4, Marianas Training Handbook.* PACOM.

U.S. Department of the Navy. (2001). *Final Integrated Natural Resources Management Plan for Navy Lands, Guam.* Plan Duration 18 Novembe 2001 to 17 November 2006. COMNAVMARIANAS.

U.S. Department of the Navy. (2003). *Integrated Natural Resources Management Plan, Farallon De Medinilla and Tinian Military Lease Areas, Commonwealth of the Northern Mariana Islands.* Plan Duration FY 03 - 12. COMNAVMARIANAS.

U.S. Department of the Navy. (2006). *Final Environmental Assessment, San Clemente Island Wastewater Treatment Plant Increase in Maximum Allowable Discharge Volume.*

U.S. Department of the Navy. (2007). *Draft Programmatic Overseas Environmental Assessment/Overseas Environmental Assessment, Exercise Valiant Shield*. COMPACFLT.

U.S. Department of the Navy. (2007). *Navy Environmental and Natural Resources Program Manual.*

U.S. Environmental Protection Agency. (1996). *National Ambient Water Quality Criteria*.

U.S. Environmental Protection Agency. (2006). *Method 8330, Appendix A: Collecting and Processing of Representative Samples for Energetic Residues in Solid Matrices from Military Training Ranges*.

U.S. Geological Survey. (2002). Newsrooom**.** *Supertyphoon Pongsona Damages Guam's Water Supplies* retrieved from http://www.usgs.gov/newsroom/article.asp?ID=312 Released: 12/19/2002.

U.S. Geological Survey. (2003). *Report for 2003GU18B: Inventory and Evaluation of Karst Features Relating to Past and Present Groundwater Flow on Rota, Commonwealth of the Northern Marianas (CNMI), in Terms of the Carbonate Island Karst Model* retrieved from http://water.usgs.gov/wrri/02-03grants_new/prog-compl-reports/2003GU18B.pdf

U.S. Geological Survey. (2005). *Construction, Geologic, and Hydrologic Data from Five Exploratory Wells on Rota, Commonwealth of the Northern Mariana Islands, 1999 Guam's Water Supplies.* Prepared in cooperation with the Commonwealth Utilities Corporation: CNMI. Open File Report 2005-1042.

U.S. Geological Survey. (2008). *Water-Related Activities of USGS in Micronesia and American Samoa. Water-Resource Assessment and Technical Assistance, Commonwealth of the Northern Mariana Islands.* Retrieved March 4, 2008 from http://hi.water.usgs.gov/studies/project_saipan.htm

Section 3.4 References: Air Quality

Bearden, Brian. Commonwealth of the Northern Mariana Islands Division of Environmental Quality. Personal communication, 23 April 2008.

Biland, Larry. U.S. Environmental Protection Agency Region 9. Personal Communication, 23 April 2008

Castro, Kevin. U.S. Environmental Protection Agency Region 9. Personal Communication, 24-25 April 2008.

Dombrowski, Sally. U.S. Environmental Protection Agency Office of Air Quality Planning and Standards. Personal Communication, 23 April 2008.

Parsons-Brinkerhoff International, Inc. (2008). *Jose D. Leon Guerrero Commercial Port of Guam – Master Plan Update 2007 Report, Public Comment Draft.*

U.S. Air Force. (1997). *Environmental effects of self-protection chaff and flares.* Headquarters Air Combat Command: Langley Air Force Base, VA. var. p. NTIS PB98-110620.

U.S. Air Force. (2006). *Final Environmental Impact Statement, Establishment and Operation of an Intelligence, Surveillance, and Reconnaissance, and Strike Capability*. Andersen Air Force Base, Guam. Volumes I and II.

U.S. Department of the Navy. (2001). *Final Environmental Impact Statement, Shock Trial of the WINSTON S. CHURCHILL (DDG 81).* Naval Sea Systems Command.

U.S. Department of the Navy. (2007). *OPNAVINST 5090.1C – Navy Environmental and Natural Resources Program Manual.*

U.S. Environmental Protection Agency. (1992). *Procedures for Emission Inventory Preparation, Volume IV: Mobile Sources.* EPA 420-R-92-009. Washington D.C.

Section 3.5 References: Airborne Noise

Air Force Center for Engineering and the Environment. (2003). [Aircraft operations data for transient aircraft collected by HQ Air Force Center for Environmental Excellence in August 2003.] Unpublished raw data.

Federal Aviation Administration. (1999). *Land Use Compatibility and Airports, a Guide for Effective Land Use Planning.*

Federal Interagency Committee on Urban Noise. (1980). *Guidelines for Considering Noise in Land Use Planning and Control,* New Jersey, D.C.: U.S. Government Printing Office.

Investigative Science and Engineering, Inc. (1997). *Typical Sound Levels.*

Morton, J.M. (1996). *The effects of aircraft overflights on endangered Mariana crows and Mariana fruit bats at Andersen Air Force Base, Guam*. Technical report prepared by the U. S. Fish and Wildlife Service for the Department of the Navy. 81pp.

U.S. Air Force. (1998). *Air Installation Compatible Use Zone Report.* Volume I. Andersen Air Force Base: Territory of Guam.

U.S. Air Force. (2000). *Environmental Assessment, Andersen Air Force Base Cargo Parachute Drop Zone*. Pacific Air Forces: 36th Air Base Wing.

U.S. Air Force. (2006). *Establishment and Operation of an Intelligence, Surveillance and Reconnaissance Strike, Andersen Air Force Base, EIS*. Andersen Air Force Base.

U.S. Department of the Navy. (1978). *Planning in the Noise Environment*, *P-970*. Naval Facilities Engineering Command.

U.S. Department of the Navy. (1988). *OPNAVINST 11010.36A, Air Installations Compatible Use Zones (AICUZ) Program.*

U.S. Department of the Navy. (1999). *Environmental Impact Statement forMilitary Training in the Marianas. Final*. Volumes I and II. Pacific Command.

U.S. Department of the Navy. (2007). *OPNAVINST 5090.1C, Environmental Compliance Afloat*.

U.S. Marine Corps. (2003). *Environmental Assessment: MOUT Training at Andersen South*.

Section 3.6 References: Marine Communities

Abraham, T., M. Beger, D. Burdick, E. Cochrane, P. Craig, G. Didonato, D. Fenner, A. Green, Y. Golbuu, J. Gutierrez, M. Hasurmai, C. Hawkins, P. Houk, D. Idip, D. Jacobson, E. Jospeh, T. Keju, J. Kuartei, S. Palik, L. Penland, S. Pinca, K. Rikim, J. Starmer, M. Trianni, S. Victor, and L. & L. Whaylen. (2004). Status of the coral reefs in Micronesia and American Samoa. Edited by R. Kelty and J. Kuartei. P; 381-409 in C. Wilkinson, Ed. *Status of Coral Reefs of the World 2004.* Townsville, Queensland: Australian Institute of Marine Science.

Artificial Reef Subcommittee. (1997). *Guidelines for marine artificial reef materials.* Fish and Wildlife Service Grant Agreement No. GS-96. Ocean Springs, Mississippi: Gulf States Marine Fisheries Commission.

Auster, P. J. & R. W. Langton. (1998). *The Effect of Fishing on Fish Habitat.* National Undersea Research Center. Univ. of Connecticut. Groton, CT. 51 p.

Baine, M. (2001). Artificial reefs: A review of their design, application, management and performance. *Ocean and Coastal Management* 44:241-259.

Barnette, M. C. (2001). *A Review of the Fishing Gear Utilized Within the Southeast Region and their Potential Impacts on Essential Fish Habitat.* National Marine Fisheries Service. Southeast Regional Office. St. Petersburg, Fl. 68p.

Bernhard R., R. P. Moyer, B. K. Walker, K. Kohler, D. Gilliam, & R. E. Dodge. (2008). A Tale of Germs, Storms, and Bombs: Geomorphology and Coral Assemblage Structure at Vieques (Puerto Rico) Compared to St. Croix (U.S. Virgin Islands). *Journal of Coastal Research*. 24(4): 1008-1021.

Birkeland, C. (1997). Status of coral reefs in the Marianas. Pages 91-100 in R.W. Grigg, & C. Birkeland, eds. *Status of Coral Reefs in the Pacific*. Honolulu, Hawaii: Sea Grant College Program, School of Ocean and Earth Science and Technology, University of Hawaii.

Blue Water. (2002). *Fatal attraction*. Retrieved 30 March 2004 from http://www.bluewatermag.com.au/dec02 feature2.asp

Boehlert, G.W. & A. Genin. (1987). A review of the effects of seamounts on biological processes. Pages 319-334 in B.H. Keating, P. Fryer, R. Batiza, & G.W. Boehlert, eds. *Seamounts, islands, and atolls*. Washington, D.C.: American Geophysical Union.

Bohnsack, J.A., D.L. Johnson, & R.F. Ambrose. (1991). Ecology of artificial reef habitats and fishes. Pages 61-107 in W. Seaman Jr., & L. M. Sprague, eds. *Artificial habitats for marine and freshwater fisheries*. San Diego, California: Academic Press.

Catanzaro, C.S. Rogers, Z. Hillis-Starr, R. Nemeth, M. Taylor, G.P. Schmahl, M.W. Miller, D.A. Gulko, J.E. Maragos, A.M. Friedlander, C.L. Hunter, R.S. Brainard, P. Craig, R.H. Richmond, G. Davis, J. Starmer, M. Trianni, P. Houk, C.E. Birkeland, A. Edward, Y. Golbuu, J. Gutierrez, N. Idechong, G. Paulay, A. Tafileichig, & N. Vander Velde. *The State of Coral Reef Ecosystems of the United States and Pacific Freely Associated States*. (2002). Silver Spring, Maryland: National Oceanic and Atmospheric Administration, National Ocean Service, National Centers for Coastal Ocean Science.

Chapman, L. (2004). *Nearshore domestic fisheries development in Pacific Island countries and territories. Draft*. Noumea, New Caledonia: Secretariat of the Pacific Community.

Commonwealth of the Northern Marianas Islands Department of Fish and Wildlife. (2005). [Map]. A map describing the location of Fish Aggregation Devices in the CNMI retrieved 13 January 2005 from http://www.dfw.gov.mp/images/FAD-map-large.jpg

Commonwealth of the Northern Marianas Islands Department of Fish and Wildlife. (2008). *Marine and Water Quality Monitoring Plan for the Commonwealth of the Northern Mariana Islands, Division of Environmental Quality and Coastal Resources Management Office, Saipan, CNMI*. 38 pp.

Commonwealth of the Northern Mariana Islands Coastal Resources Management. (2001). *Shipwrecks, groundings, marine debris and dredging*. Deep-Sea Research 38(2):185-199. Retrieved 13 January 2005 from http://www.crm.gov.mp/marine/wreck_debris/debris.htm

Daniel, R. & Minton, D. (2004). *Inventory & monitoring program, Pacific Island Network Monitoring Plan--Appendix A: Marine report*. Retreived from http://www.nature.nps.gov/im/units/pacn/monitoring/plan/2004/pacn_Saipan, CNMI: National Park Service.

Day, J.W., C.A.S. Hall, W.M. Kemp, & A. Yáñez-Arancibia. (1989). *Estuarine Ecology*. New York, New York: John Wiley & Sons, Inc.

Department of Agriculture, Division of Aquatic and Wildlife Resources. (2004). *Sport fish restoration: Locations of fish aggregating devices, Guam*. Mangilao, Guam.

Duenas & Associates (Saipan) Inc. (1997). *Saipan lagoon use management plan, survey of sea cucumbers and fish in the Saipan lagoon, Northern Mariana Islands*. D&A (ES) Rept. No. 97-6(F). Prepared for Coastal Resources Management Office, Department of Lands and Natural Resources, Government of the Northern Mariana Islands, San Jose, Saipan, MP.

Eldredge, L.G. (1979). *Marine biological resources within the Guam seashore study area and the War in the Pacific National Historical Park*. (Technical Report No. 57). Mangilao, Guam: University of Guam Marine Laboratory. Submitted to National Park Service: U.S. Department of Interior.

Eldredge, L.G. (1983). *Summary of environmental and fishing information on Guam and the Commonwealth of the Northern Mariana Islands: Historical background, description of the islands, and review of the climate, oceanography, and submarine topography*. (NOAA Technical Memorandum NMFS-SWFC-40:1-181).

Eldredge, L.G., R. Dickinson, & S. Moras, eds. (1977). *Marine survey of Agat Bay*. (Technical Report No. 31.) Mangilao, Guam: University of Guam Marine Laboratory. Submitted to Guam Oil and Refinery Co., Inc.

Embley, R.W., E.T. Baker, W.W. Chadwick, J.E. Lupton, J.A. Resing, G.J. Massoth, & K. Nakamura. (2004). *Explorations of Mariana Arc volcanoes reveal new hydrothermal systems.* EOS 85(4):37-44.

Fedorov, V.V. & S.D. Chistikov. (1985). Landscapes of seamounts as indicators of the biological productivity of the surrounding waters. In M.E. Vinogradev and M.V. Flint, eds, *Biological bases of the commercial exploitation of the open areas of the ocean.* Academy of Science of the U.S.S.R., Commission on problems of the world ocean. Published by Nauka Publ., Moscow, p. 221-230. Translation No. 126. Honolulu, Hawaii: U.S. Department of Commerce. Translated from the Russian by Wilvan G. Van Campen for the SWFC Honolulu Laboratory, NMFS, NOAA. April 1988. Retrieved from ftp://daac.gsfc.nasa.gov/data /czcs/level_3/monthly_data/subsets/Chlor/

Friedlander, A., Aeby, G., Brainard, R., Clark, A., DeMartini, E., et al. The state of coral reef ecosystems of the northwestern Hawaiian islands. In: Waddell J. , editor. *The state of coral reef ecosystems of the United States and Pacific freely associated states: 2005 NOAA Technical Memorandum NOS NCCOS 11.* Silver Spring (Maryland): NOAA/NCCOS Center for Coastal Monitoring and Assessment's Biogeography Team; 2005. p. 522. editor.

Galkin, S.V. (1997). Megafauna associated with hydrothermal vents in the Manus Back-Arc Basin (Bismark Sea). *Marine Geology* 142:197-206.

Hamilton, Jr., A. N. (2000). *Gear Impacts on Essential Fish Habitat in the Southeastern Region.* National Marine Fisheries Service: Southeast Fisheries Science Center.

Hashimoto, J., S. Ohta, K. Fujikura, & T. Miura. (1995). Microdistribution pattern and biogeography of the hydrothermal vent communities of the Minami-Ensei Knoll in the Mid Okinawa Trough, Western Pacific. *Deep-Sea Research* I 42(4):577-598.

Hessler, R.R. & P.F. Lonsdale. (1991). Biogeography of Mariana Trough hydrothermal vent communities. *Deep-Sea Research* 38(2):185-199.

Higgins, H.W. & D.J. Mackey. (2000). Algal class abundances, estimated from chlorophyll and carotenoid pigments, in the western Equatorial Pacific under El Niño and non-El Niño conditions. *Deep-Sea Research* I 47:1461-1483.

Humphris, S.E. (1995). Hydrothermal processes at mid-ocean ridges. *Reviews of Geophysics Supplement*, Vol. 33. Retrieved January 13, 2008 from http://www.agu.org/revgeophys/humphr01/humphr01.html

Johnson, K. A. (2002). *A Review of National and International Literature on the Effects of Fishing on Benthic Habitat.* (NOAA Tech. Memo. NMFS-F/SPO-57).

Kato, C., L. Yi, Y. Nogi, Y. Nakamura, J. Tamaoka, & K. Horikoshi. (1998). Extremely barophilic bacteria isolated from the Mariana Trench, Challenger Deep, at a depth of 11,000 meters. *Applied Environmental Microbiology* 64(4):1510-1513.

Kennett, J.P. (1982). *Marine geology*. Englewood Cliffs, New Jersey: Prentice-Hall, Inc.

Klima, E.F. & D.A. Wickham. (1971). Attraction of coastal pelagic fishes with artificial structures. *Transactions of the American Fisheries Society*. 100:86-99.

Kojima, S. 2002. Deep-sea chemoautosynthesis-based communities in the northwestern Pacific. *Journal of Oceanography* 58:343-363.

Kolinski, S.P., D.M. Parker, L.I. Ilo, & J.K. Ruak. (2001). *An assessment of the sea turtles and their marine and terrestrial habitats at Saipan, Commonwealth of the Northern Mariana Islands*. Micronesia 34(1):55-72.

Le Bouteiller, A., J. Blanchot, & M. Rodier. (1992). Size distribution patterns of phytoplankton in the western Pacific: Towards a generalization for the tropical open ocean. *Deep-Sea Research* 39(5):805-823.

Lovell, C.R. (2005). Belowground interactions among salt marsh plants and microorganisms. In: E. Kristensen, J.E. Kostka, & R.H. Hease (eds.) *Interactions Between Macro- and Microorganisms in marine Sediments*. Pp. 61-83. Coastal and Estuarine Studies Volume 60. American Geophysical Union. Washington, D.C.

Mariana Trench. (2003). *The Mariana Trench – Biology*. Retrieved January 18, 2005 from http://www.marianatrench.com/mariana_trench-biology_001.htm

McKenzie, L.J. and M.J. Rasheed. (2006). Seagrasses: Pohnpei Island and Ahnd Atoll Marine Assessment: Technical report of survey conducted 26 October – 3 November 2005. (Seagrass-Watch HQ, DPI&F, Cairns). 60pp.

McMullin, E.R., D.C. Bergquist, & C.R. Fisher. (2000). Metazoans in extreme environments: Adaptations of hydrothermal vent and hydrocarbon seep fauna. *Gravitational and Space Biology Bulletin* 13(2):13-23.

Micronesian Divers Association, Inc. (2005). *American Tanker*. Retrieved May 5, 2005 from http://www.mdaguam.com/tanker.htm

Minerals Management Service. (2002). *Gulf of Mexico OCS Oil and Gas Lease Sale 181, Eastern Planning Area, Final Environmental Impact Statement*. Volume 1 & 2. OCS EIS/EA MMS 2002-051. New Orleans: Minerals Management Service.

Morgan, L.E. & R. Chuenpagdee. (2003). Shifting gears, addressing the collateral impacts of fishing methods in U.S. waters. *Marine Conservation Biology Institute*. 40 pp.

Myers, R. (1999). *Micronesian reef fishes: A comprehensive guide to the coral reef fishes of Micronesia.* 3d ed. Barrigada, Territory of Guam: Coral Graphics.

National Atmospheric and Space Administration. (1998). Goddard Earth Sciences Data and Information Services Center, Distributed Active Archive Center. Retrieved January 23, 2004.

National Centers for Coastal Ocean Science/National Oceanic and Atmospheric Administration. (2005). [CD-ROM]. *Shallow-water benthic habitats of American Samoa, Guam, and the Commonwealth of the Northern Mariana Islands*. (NOAA Technical Memorandum NOS-CCMA-8:1-48).

National Oceanic and Atmospheric Association. (2004). *Derelict Vessels in Saipan, Commonwealth of the Northern Marianas Islands.* NOAA Coral Reef News 1(4):3.

National Research Council. (2002). *Effects of Trawling and Dredging on Seafloor Habitats*. National Academy Press. 126 p.

Nybakken, J.W. (1997). *Marine Biology: An ecological approach*. 4th ed. Menlo Park, California: Addison Wesley Educational Publishers, Inc.

Ogawa, Y., K. Kobayashi, H. Hotta, & K. Fujioka. (1997). Tension cracks on the oceanward slopes of the northern Japan and Mariana Trenches. *Marine Geology* 141:111-123.

Pacific Basin Environmental Consultants, Inc. (1985). *CNMI marine parks management plan*. Saipan, CNMI: Coastal Resources Management Office.

Parsons, T.R., M. Takahashi, & B. Hargrave. (1984). *Biological oceanographic processes*. 3d ed. Oxford, United Kingdom: Pergamon Press.

Paulay, G. (2003). *Marine biodiversity of Guam and the Marianas: overview*. Micronesica (35-36):3-25.

Paulay, G. (2005). Personal communication, comments received from pre-final draft of Marine Resources Assessment for the Marianas Operating Area.

Paulay, G., L. Kirkendale, G. Lambert, & C. Meyer. (2002). Anthropogenic biotic interchange in a coral reef ecosystem: A case study from Guam. *Pacific Science* 56(4):403-422.

Phillips, R.C. & E.G. Menez. (1988). *Seagrasses*. Smithsonian contributions to the Marine Sciences 34:1-104.

Randall, R.H. (1985). *Habitat geomorphology and community structure of corals in the Mariana Islands.* Pp 261-266 in C. Gabrie and M. Harmelin, eds. Proceedings of the 5th International Coral Reef Congress, Tahiti. Volume 6. Polynesia: Ecole Pratique des Hautes Etudes.

Randall, R.H. (1995). Biogeography of the reef-building corals in the Mariana and Palau Islands in relation to back-arc rifting and the formation of the Eastern Philippine Sea. *Natural History Research* 3(2):193-210.

Randall, R.H. (2003). *An annotated checklist of hydrozoan and scleractinian corals collected from Guam and other Mariana Islands.* Micronesica 35-36:121-137.

Randall, R.H., H.G. Siegrist Jr., & A.W. Siegrist. (1984) Community structure of reef-building corals on a recently raised Holocene reef on Guam, Mariana Islands. *Palaeontographica Americana* 54:394-398.

Restore America's Estuaries/Estuarine Research Foundation. (1999). *Principles of estuarine habitat restoration: Working together to restore America's estuaries.* (Report on the RAE-ERF partnership – year one – September 1999). Arlington, Viginia/Port Republic, Maryland: RAE/ERF.

Richer de Forges, B., J.A. Koslow, & G.C.B. Poore. (2000). Diversity and endemism of the benthic seamount fauna in the southwest Pacific. *Nature* 405:944-947.

Rock, T. (1999). *Diving & snorkeling: Guam & Yap.* 2d ed. Victoria, Australia: Lonely Planet Publications.

Rogers, A.D. (1994). The biology of seamounts. Pages 306-350 in J. H. Blaxter, and A. J. Southward, eds. *Advances in Marine Biology*, volume 30. San Diego: Academic Press.

Rountree, R.A. (1990). Community structure of fishes attracted to shallow water fish aggregation devices off South Carolina, U.S.A. *Environmental Biology of Fishes* 29:241-262.

Samples, K.C. & J.R. Hollyer. (1989). Economic considerations in configuring fish aggregation device networks. *Bulletin of Marine Science* 44(2):863-872.

Scavia, D. (1988). On the role of bacteria in secondary production. *Limnology and Oceanography*. 33(5): 1220-1224.

Scott, D.A. (1993). A directory of wetlands in Oceania retrieved January 13 from http://www.wetlands.org/inventory&/OceaniaDir/Contents.htm

Seaman, W., Jr. & A. C. Jensen. (2000). Purposes and practices of artificial reef evaluation. Pages 1-19 in W. Seaman Jr., ed. *Artificial reef evaluation with application to natural marine habitats*. New York, New York: CRC Press.

Starmer, J., ed. (2005). The state of coral reef ecosystems of the Commonwealth of the Northern Mariana Islands. Pages 399-441 in J.E. Waddell, ed. *The state of coral reef ecosystems of the United States and Pacific Freely Associated States: 2005*. (NOAA Technical Memorandum NOSNCCOS-11).

Starmer, J., M.S. Trianni, & P. Houk. (2002). *Status of coral reefs in the Commonwealth of the Northern Mariana Islands*. Pages 195-204 in D.D. Turgeon, R.G. Asch, B.D. Causey, R.E. Dodge, W. Jaap, K. Banks, J. Delaney, B.D. Keller, R. Speiler, C.A. Matos, J.R. Garcia, E. Diaz, D.

Strayer, D. (1988). On the limits to secondary production. *Limnology and Oceanography* 33(5):1217-1220.

Stüben, D., S.H. Bloomer, N.E. Taïbi, T. Neumann, V. Bendel, U. Püschel, A. Barone, A. Lange, W. Shiying, L. Cuizhung, & Z. Deyu. (1992). First results of sulfur-rich hydrothermal activity from an island-arc environment: Esmerelda Bank in the Mariana Arc. *Marine Geology* 103:521-528.

Thompson, P.L. (2005). *76th SEABEES of World War II: 76th Bees – An untold story* retrieved September 9, 2005 from http://mysite.verizon.net/vzeo0pwz/76thseabeesworldwar2/id3.html

Thurman, H.V. (1997). *Introductory oceanography*. 8th ed. Upper Saddle River, New Jersey: Prentice Hall.

Trianni, M.S. & C.C. Kessler. (2002). Incidence and strandings of the spinner dolphin, *Stenella longirostris*, in Saipan Lagoon. *Micronesica* 34(2):249-260.

Tsuda, R.T., F.R. Fosberg, & M.H. Sachet. (1977). Distribution of seagrasses in Micronesia. *Micronesica* 13(2):191-198.

Uchida, R. (1983). *Summary of environmental and fishing information on Guam and the Commonwealth of the Northern Mariana Islands: A review of the plankton communities and fishery resources*. (NOAA Technical Memorandum NOAA-TM-NMFS-SWFC-33:1-159).

U.S. Department of the Navy. (1999). *Wetland delineation data layers for Guam Navy lands*. Received 4 May 2005 from Robert W. Wescom, Natural Resources Manager, Commander, U.S. Naval Forces Marianas, Guam.

U.S. Department of the Navy. (2000). *COMNAVMARIANAINST 3500.4, Marianas Training Handbook*. Prepared for Commander in Chief, U.S. Pacific Command Representative, Guam and the Commonwealth of the Mariana Islands.

U.S. Department of the Navy. (2003). *Integrated natural resources management plan--Farallon de Medinilla and Tinian military lease areas--Commonwealth of the Northern Mariana Islands*. Plan duration: FY 03-12. Prepared for Commander: U.S. Naval Forces Marianas by Helber Hastert & Fee, Planners.

U.S. Department of the Navy. (2005). *Marine Resources Assessment for the Marianas Operating Area*. Pacific Division: Naval Facilities Engineering Command, Pearl Harbor, Hawaii. Contract # N62470-02-D-9997, CTO 0027. Prepared by Geo-Marine, Inc., Plano, Texas.

U.S. Geological Survey. (1978). [Map]. Topographic map of Guam Mariana Islands. Reston, Virginia: United States Geological Survey.

Valiela, I. (1995). *Marine ecological processes*. 2d ed. New York, New York: Springer-Verlag.

Vinogradov, M.Y. & N.V. Parin. (1973). On the vertical distribution of macroplankton in the tropical Pacific. *Oceanology* 13:104-113.

Whaylen, (2004). Status of the coral reefs in Micronesia and American Samoa. Edited by R. Kelty, & J. Kuartei. Pages 381-409 in C. Wilkinson, ed. *Status of Coral Reefs of the World: 2004.* Townsville, Queensland: Australian Institute of Marine Science.

Wilder, M.J. (1976). Estuarine and mangrove shorelines. Pages 157-189 in Randall, R.H. and L.G. Eldredge, eds. *Atlas of the Reefs and Beaches of Guam.* Agana, Guam: Guam Bureau of Planning.

Wilson, R.R. & R.S. Kaufmann. (1987). Seamount biota and biogeography. Pages 355-377 in B. H. Keating, P. Fryer, R. Batiza, & G. W. Boehlert, eds. *Seamounts, islands, and atolls*. Washington, D.C.: American Geophysical Union.

Section 3.7 References: Marine Mammals

Abend, A.G. & T.D. Smith. (1999). Review of Distribution of the Long-finned Pilot Whale (*Globicephala melas*) in the North Atlantic and Mediterranean. *NOAA Technical Memorandum NMFS-NE-117*.

Aburto, A., D.J., Roundtry, & D.L. Danzer. (1997). *Behavioral response of blue whales to active signals*. (Technical Report). Naval Command, Control, and Ocean Surveillance Center: San Diego, CA.

Acevedo-Gutierrez, A, D.A. Croll, & B.R. Tershy. (2002). High feeding costs limit dive time in the largest whales. *Journal of Experimental Biology* 205:1747-1753.

Advisory Committee On Acoustic Impacts To Marine Mammals. (2006). (Report submitted to the U.S. Marine Mammal Commission. February 1, 2006). 136 pp.

Aguilar, A. (2002). Fin whale Balaenoptera physalus. Pages 435-438 in Perrin, W. F., B. Würsig, & J. G. M. Thewissen, eds. *Encyclopedia of marine mammals*. San Diego, California: Academic Press.

Aguilar, A. & S. Lens. (1981). *Preliminary report on Spanish whaling activities*. (Reports of the International Whaling Commission, 31:639-643).

Aguilar, A. & C. Lockyer. (1987). Growth, physical maturity, and mortality of fin whales *(Balaenoptera physalus)* inhabiting the temperate waters of the northeast Atlantic. *Canadian Journal of Zoology* 65:253-264.

Alexander, J.W., M.A. Solangi, & L.S. Riegel. (1989). Vertebral osteomyelitis and suspected diskospondylitis in an Atlantic bottlenose dolphin (*Tursiops truncatus*). *Journal of Wildife Diseases* 25:118-121.

Allen, K.R. (1980). *Conservation and management of whales*. Seattle, WA: University of Washington Press.

Alling, A.K. & R. Payne. (1991). In*:* Leatherwood, S. (ed.). *Song of the Indian Ocean blue whale, Balaenoptera musculus.* Special issue on the Indian Ocean sanctuary.

Amano, M. & M. Yoshioka. (2003). *Sperm whale diving behavior monitored using a suction-cup attached TDR tag Marine Ecology Progress Series* 258:291-295.

Amemiya, T. (1981). Qualitative response models: a survey. *Journal of Economic Literature* 19:1483-1536.

Amesbury, S., R. Bonito, R. Chang, L. Kirkendale, C. Meyer, G. Paulay, R. Ritson-Williams, & T. Rongo. (2001). *Marine biodiversity resource survey and baseline reef monitoring survey of the Haputo Ecological Reserve Area, COMNAVMARIANAS. Final*. Mangilao, Guam: Marine Laboratory, University of Guam.

André, M., M. Terada, & Y. Watanabe. (1997). Sperm Whale (*Physeter macrocephalus*) Behavioral Response after the Playback of Artificial Sounds. *Reports of the International Whaling Commission 47:499-504.*

Andrew, R.K., B.M. Howe, & J.A. Mercer. (2002). Ocean ambient sound: Comparing the 1960s with the 1990s for a receiver off the California coast. *Journal of the Acoustic Society of America 3:65-70.*

Andrews, K.R., L. Karczmarski, W.W.L. Au, S.H. Rickards, C.A. Vanderlip, & R.J. Toonen. (2006). Patterns of genetic diversity of the Hawaiian spinner dolphin. *Atoll Research Bulletin 543:65-73*.

Angliss, R.P. & R.B. Outlaw. (2007). *Alaska Marine Mammal Stock Assessments, 2006.* (NOAA Technical Memorandum NMFS-AFSC-168). 255pp.

Anonymous. (2002). Baffling boing identified. *Science* 298:2125.

American National Standards Institute, Inc. (1976). *American National Standard Acoustical Terminology.* New York.

American National Standards Institute, Inc. (1992). *Engineering Method for the Determination of Sound Power Levels of Noise Sources Using Intensity*. ANSI-S12.12-1992

Archer, F.I. & W.F. Perrin. (1999). *Stenella coeruleoalba*. *Mammalian Species* 603:1-9.

Arons, A.B. (1954). Underwater Explosion Shock Wave Parameters at Large Distances from the Charge. *Journal of the Acoustical Society of America* 26:343.

Arruda, J., A. Costidis, S.Cramer, D.R. Ketten, W. McLellan, E.W. Montie, M. Moore, & S. Rommel. (2007). Odontocete Salvage, Necropsy, Ear Extraction, and Imaging Protocols, edited by N.M. Young. *Ocean Research, Conservation and Solutions (ORCAS) and ONR*. 171 pp.

Arveson, P.T. & D.J. Vendittis. (2006). Radiated noise characteristics of a modern cargo ship. *Journal of the Acoustic Society of America* 107:118-129.

Ashford, J.R., P.S. Rubilar, & A.R. Martin. (1996). Interactions between cetaceans and long-line fishery operations around South Georgia. *Marine Mammal Science* 12:452-457.

Atkins, N. & S.L. Swartz (eds.). (1989). *Proceedings of the Workshop to Review and Evaluate Whale Watching Programs and Management Needs.* November 14-16, 1988, Monterey, California. Center for Marine Conservation: Washington D.C. 53 pp.

Atlantic Undersea Test and Evaluation Center. (1995). Environmental Review for the Atlantic Undersea Test and Evaluation Center (AUTEC). Department of the Navy: Naval Undersea Warfare Center, Key West, FL.

Au, W.W.L. (1993). *The sonar of dolphins*. Springer-Verlag: New York. 277 pp.

Au, W.W.L. & M. Green. (2000). Acoustic Interaction of Humpback Whales and Whale-watching Boats. *Marine Environmental Research* 49:469-481.

Au, D.W.K. & W.L. Perryman. (1985). Dolphin habitats in the eastern tropical Pacific. *Fishery Bulletin 83:623-643.*

Au, W.W.L., A.N. Popper, & R.R. Fay. (2000). *Hearing by whales and dolphins*. New York, New York: Springer-Verlag.

Au, W.W.L., J. Darling, & K. Andrews. (2001). High-frequency harmonics and source level of humpback whale songs. *Journal of the Acoustical Society of America* 110:2770.

Au, W.W.L. & D. Herzing. (2003). Echolocation signals of wild Atlantic spotted dolphin (*Stenella frontalis*). *Journal of the Acoustical Society of America* 113:598-604.

Au, W.W.L., J.K.B. Ford, J.K. Horne, K.A. & Newman, Allman. (2004). Echolocation signals of free-ranging killer whales (*Orcinus orca*) and modeling of foraging for Chinook salmon (*Oncorhynchus tshawytscha*). *Journal of the Acoustical Society of America* 115:901-909.

Au, W.W.L, A.A. Pack, M.O. Lammers, L.H. Herman, M.H. Deakos, & K. Andrews. (2006). Acoustic properties of humpback whale songs. *Journal of the Acoustical Society of America* 120:1103-1110.

Baillie, J. & B. Groombridge. (1996). 1996 ICUN red list of threatened animals. *International Union for the Conservation of Nature*. 312 pp.

Baird, R.W. (1998). An interaction between Pacific white-sided dolphins and a neonatal harbor porpoise. *Mammalia* 62:129-134.

Baird, R.W. (2000). The killer whale: Foraging specializations and group hunting. Pages 127-153 in J.Mann, R.C. Connor, P.L. Tyack and H. Whitehead, eds. *Cetacean societies: Field studies of dolphins and whales*. Chicago: University of Chicago Press.

Baird, R.W. (2002). False killer whale *Pseudorca crassidens*. Pages 411-412 in W.F. Perrin, B. Würsig, & J.G.M. Thewissen, eds. *Encyclopedia of marine mammals*. San Diego: Academic Press.

Baird, R.W. (2005). Sightings of dwarf (*Kogia sima*) and pygmy (*K. breviceps*) sperm whales from the main Hawaiian Islands. *Pacific Science* 59:461-466.

Baird, R.W., D. Nelson, J. Lien, & D.W. Nagorsen. (1996). The status of the pygmy sperm whale, *Kogia breviceps,* in Canada. *Canadian Field-Naturalist* 110:525-532.

Baird, R.W., A.D. Ligon, & S.K. Hooker. (2000). *Sub-surface and night-time behavior of humpback whales off Maui, Hawaii: A preliminary report.* (Report prepared for the Hawaii Wildlife Fund, Paia, Hawaii).

Baird, R.W., A.D. Ligon, S.K. Hooker & A.M. Gorgone. (2001). Subsurface and nighttime behavior of pantropical spotted dolphins in Hawai'i. *Canadian Journal of Zoology* 79:988-996.

Baird, R.W., J.F. Borsani, M.B. Hanson & P.L. Tyack. (2002). Diving and night-time behavior of long-finned pilot whales in the Ligurian Sea. *Marine Ecology Progress Series* 237:301-305.

Baird, R.W., D.J. McSweeney, D.L. Webster, A.M. Gorgone, & A.D. Ligon. (2003a). *Studies of odontocete population structure in Hawaiian waters: Results of a survey through the main Hawaiian Islands in May and June 2003.* (Report prepared for the National Marine Fisheries Service, National Marine Mammal Laboratory, Seattle, Washington).

Baird, R.W., M.B. Hanson, E.E. Ashe, M.R. Heithaus & G.J. Marshall. (2003b). *Studies of foraging in "southern resident" killer whales during July 2002: dive depths, bursts in speed, and the use of a "crittercam" system for examining sub-surface behavior.* (Report prepared under Order number AB133F-02-SE-1744 for the NMFS-NMML).

Baird, R.W., D.J. McSweeney, A.D. Ligon, & D.L. Webster. (2004). *Tagging feasibility and diving of Cuvier's beaked whales (Ziphius cavirostris) and Blainville's beaked whales (Mesoplodon densirostris) in Hawaii.* Order No. AB133F-03-SE-0986. Prepared for Southwest Fisheries Science Center: National Marine Fisheries Service, La Jolla, California by Hawaii Wildlife Fund, Volcano, Hawaii.

Baird, R.W., M.B. Hanson & L.M. Dill. (2005). Factors influencing the diving behaviour of fish-eating killer whale: Sex differences and diel and interannual variation in diving rates. *Canadian Journal of Zoology* 83:257-267.

Baird, R.W., D.L. Webster, D.J. McSweeney, A.D. Ligon, G.S. Schorr & J. Barlow. (2006). Diving behaviour of Cuvier's (*Ziphius cavirostris*) and Blainville's (*Mesoplodon densirostris*) beaked whales in Hawai'i. *Canadian Journal of Zoology* 84:1120-1128.

Baker, C.S. & L.M. Herman. (1981). Migration and local movement of humpback whales (*Megaptera novaeangliae*) through Hawaiian waters. *Canadian Journal of Zoology* 59:460-469.

Baker, C.S. & L.M. Herman. (1987). Alternative population estimates of humpback whales (*Megaptera novaeangliae*) in Hawaiian waters. *Canadian Journal of Zoology* 65:2818-2821.

Baker, C.S., L. Medrano-Gonzalez, J. Calambokidis, A. Perry, F. Pichler, H. Rosenbaum, J.M. Straley, J. Urban-Ramirez, M. Yamaguchi, & O. Von Ziegesar. (1998). Population structure of nuclear and mitochondrial DNA variation among humpback whales in the North Pacific. *Molecular Ecology* 7:695-707.

Baker, J.D. & T.C. Johanos. (2004). Abundance of the Hawaiian monk seal in the main Hawaiian Islands. *Biological Conservation* 116:l03-110.

Balcomb, K.C. (1987). *The whales of Hawaii, including all species of marine mammals in Hawaiian and adjacent waters*. San Francisco: Marine Mammal Fund.

Balcomb, K.C. (1989). Baird's beaked whale *Berardius bairdii Stejneger*, 1883: Arnoux's beaked whale *Berardius arnuxii Duvernoy*, 1851. Pages 261-288 in S.H. Ridgway and R. Harrison, eds. *Handbook of marine mammals, Volume 4: River dolphins and the larger toothed whales*. London: Academic Press.

Ballance, L.T., R.L. Pitman, & P.C. Fiedler. (2006). Oceanographic influences on seabirds and cetaceans of the eastern tropical Pacific: A review. *Progress in Oceanography* 69:360-390.

Banister, J.L. & E. Mitchell. (1980). North Pacific sperm whale stock identity: distributional evidence from Maury and Townsend charts. *Reports of the International Whaling Commision. Special Issue* 2:219–223.

Baraff L.S. & M.T. Weinrich. (1993). Separation of humpback whale mothers and calves on a feeding ground in early autumn. *Marine Mammal Science* 7:49-54

Bargu, S., C.L. Powell, Z. Wang, G.J. Doucette, & M.W. Silverc. (2008). Note on the occurrence of Pseudo-nitzschia australis and domoic acid in squid from Monterey Bay, CA (USA). *Harmful Algae* 7:45-51.

Bartberger, C.L. (1965). *Lecture Notes on Underwater Acoustics*. (NADC Report NADC=WR-6509, Naval Air Development Center Technical Report: Johnsville, PA, 17 May [AD 468 869]).

Barlow, J. (1999). Trackline detection probability for long-diving whales. Pages 209-221 in G.W. Garner, S.C. Amstrup, J.L. Laake, B.F.J. Manly, L.L. McDonald, & D.G. Robertson, eds. *Marine mammal survey and assessment methods*. Brookfield, Vermont: A.A. Balkema.

Barlow, J. (2003). *Cetacean abundance in Hawaiian waters during summer/fall of 2002.* (Southwest Fisheries Science Center Administrative Report LJ-03-13). La Jolla, California: National Marine Fisheries Service.

Barlow, J. (2006). Cetacean abundance in Hawaiian waters estimated from a summer/fall survey in 2002. *Marine Mammal Science* 22:446–464.

Barlow, J. & T. Gerrodette. (1996). *Abundance of cetaceans in California waters based on 1991 and 1993 ship surveys*. (U.S. Department of Commerce: NOAA Technical Memorandum, NMFS-SWFSC-233). 15pp.

Barlow, J. & B.L. Taylor. (2005). Estimates of sperm whale abundance in the northeastern temperate Pacific from a combined acoustic and visual survey. *Marine Mammal Science* 21:429-445.

Barlow, J., S. Rankin, E. Zele, & J. Appler. (2004). *Marine mammal data collected during the Hawaiian Islands Cetacean and Ecosystem Assessment Survey (HICEAS) conducted aboard the NOAA ships McArthur and David Starr Jordan, July - December 2002*. (NOAA Technical Memorandum NMFS-SWFSC-362:1-39).

Barlow, J. & R. Gisiner. (2006). Mitigating, monitoring and assessing the effects of anthropogenic sound on beaked whales. *Journal of Cetacean Management and Research* 7: 239–249.

Barlow, J. & K.A. Forney. (2007). Abundance and population density of cetaceans in the California Current ecosystem. *Fisheries Bulletin* 105:509–526.

Bartberger, C.L. (1965). *Lecture Notes on Underwater Acoustics*. (NADC Report NADC-WR-6509, Naval Air Development Center, Johnsville, PA, 17 May 1965 [AD 468 869]).

Bartholomew, G.A., & C.L. Hubbs. (1960). Population growth and seasonal movements of the northern elephant seal, *Mirounga angustirostris* (1). *Mammalia* 24:313-324.

Bartholomew, G.A. & N.E. Collias. (1962). The role of vocalization in the social behavior of the northern elephant seal. *Animal Behaviour* 10:7-14.

Bauer, G.B. (1986). *The behavior of humpback whales in Hawaii and modifications of behavior induced by human interventions*. Univ. Hawaii, Honolulu, Dissertation.

Bauer, G. B. & L.M. Herman. (1986). *Effects of vessel traffic on the behavior of humpback whales in Hawaii*. (Final Report to the National Marine Fisheries Services). 151 pp.

Bauer, G.B., M. Fuller, A. Perry, J.R. Dunn, & J. Zoeger. (1985). Magnetoreception and biomineralization of magnetite in cetaceans. In: J.L. Kirschvink, D.S. Jones and B.J. MacFadden, eds. *Magnetite Biomineralization and Magnetoreception in Organisms*. Plenum Press, New York. pp. 489-507.

Bauer, G.B., J.R. Mobley, & L.M. Herman. (1993). Responses of wintering humpback whales to vessel traffic. *Journal of the Acoustical Society of America* 94:1848.

Baumgartner, M.F. (1997). The distribution of Risso's dolphin (*Grampus griseus*) with respect to the physiography of the northern Gulf of Mexico. *Marine Mammal Science* 13:614-638.

Baumgartner, M.F., K.D. Mullin, L.N. May, & T.D. Leming. (2001). Cetacean habitats in the northern Gulf of Mexico. *Fishery Bulletin* 99:219-239.

Baumgartner, M.F. & B.R. Mate. (2003). Summertime foraging ecology of North Atlantic right whales. *Marine Ecology Progress Series* 264:123-135.

Bazua-Duran, & W.W.L. Au. (2002). The whistles of Hawaiian spinner dolphins. *Journal of the Acoustical Society of America* 112:3064-3972.

Beach, D.W. & M.T. Weinrich. (1989). Watching the Whales: Is An Educational Adventure for Humans Turning Out to be Another Threat for Endangered Species? *Oceanus* 32:84-88.

Beamish, P. & E. Mitchell. (1973). Short pulse length audio frequency sounds recorded in the presence of a minke whale (*Balaenoptera acutorostrata*). *Deep-Sea Research 20:375-386*.

Bejarano, A.C., F.M. Van dolah, F.M. Gulland, & L. Schwacke. (2007). Expousre assessment of the biotoxin domoci acid in California sea lions: application of a bioenergetic model. *Marine Ecology Progress Series* 345:293-304.

Benoit-Bird, K.J. (2004). Prey caloric value and predator energy needs: foraging predictions for wild spinner dolphins. *Marine Biology* 45:435–444.

Benoit-Bird, K.J., W.W.L. Au, R.E. Brainard, & M.O. Lammers. (2001). Diel horizontal migration of the Hawaiian mesopelagic boundary community observed acoustically. *Marine Ecology Progress Series* 217:1-14.

Benoit-Bird, K.J. & W.W.L. Au. (2003). Prey dynamics affect foraging by a pelagic predator (*Stenella longirotris*) over a range of spatial and temporal scales. *Behavioral Ecology and Sociobiology* 53:364-373.

Benoit-Bird, K.J. & W.W.L. Au. (2004). Diel migration dynamics of an island-associated sound-scattering layer. *Deep-Sea Research* I. 51:707-719.

Benson, S.R., D.A.Croll, B.B.Marinovic, F.P.Chavez, & J.T.Harvey. (2002). Changes in the cetacean assemblage of a coastal upwelling ecosystem during El Nino 1997-98 and La Nina 1999. *Progress in Oceanography* 54:279-291.

Beranek, L.L. (1986). Acoustics. *American Institute of Physics, Inc.,* New York.

Bernard, H.J. & S.B. Reilly. (1999). Pilot whales Globicephala Lesson, 1828. Pages 245-279 in S.H. Ridgway and R. Harrison, eds. *Handbook of marine mammals. Volume 6: The second book of dolphins and the porpoises.* San Diego: Academic Press.

Berzin, A. A. & A. A. Rovnin. (1966). The distribution and migrations of whales in the northeastern part of the Pacific, Chukchi and Bering Seas. Izvestiya Tikhookeanskogo Nauchno-Issledovatel'skogo Institut Rybnogo Khozyaistva I Okeanografii 58:179-207. (Translated by Bureau of Commercial Fisheries, U. S. Fish and Wildlife Service, Seattle, 1968, pp. 103-136. *In* K. I. Panin (ed.), *Soviet Research on Marine Mammals of the Far East.).*

Best, P.B. (1992). Catches of fin whales in the North Atlantic by the M.V. *Sierra* (and associated vessels). *Reports of the International Whaling Commission* 42:697-700.

Best, P.B. (1993). Increase rates in severely depleted stocks of baleen whales. ICES Journal of *Marine Science* 50:169-186.

Best, P.B. & C.H. Lockyer. (2002). Reproduction, growth and migrations of sei whales *Balaenoptera borealis* off the west coast of South Africa in the 1960s. *South African Journal of Marine Science* 24:111-133.

Best, P.B., D.S. Butterworth, & L.H. Rickett. (1984). An assessment cruise for the South African inshore stock of Bryde's whales (*Balaenoptera edeni*). *Reports of the International Whaling Commission* 34:403-423.

Birkeland, C. (1977). *Surrounded by whales*. Press Release: Islander, 12 June, pp. 13-15.

Bjørge, A. (2002). How persistent are marine mammal habitats in an ocean of variability? Pages 63-91 in P.G.H. Evans and J.A. Raga, eds. *Marine mammals: Biology and conservation*. New York: Kluwer Academic/Plenum Publishers.

Bonnell, M.L. & M.D. Dailey. (1993). Marine mammals. Pp. 604–681 in *Ecology of the Southern California Bight.* (M.D. Dailey, D.J. Reish, & J.W. Anderson, eds.), University of California Press, CA. 926 pp.

Borggaard, D., J. Lien, & P. Stevick. (1999). Assessing the effects of industrial activity on large cetaceans in Trinity Bay, Newfoundland (1992-1995). *Aquatic Mammals* 25:149-161.

Borell, A. (1993). PCB and DDTs in blubber of cetaceans from the northeastern North Atlantic. *Marine Pollution Bulletin* 26:146-151.

Borrooah, V.K. (2002). *Logit and probit. Ordered and multinomial models*. SAGE Publications, Inc., Newbury Park, California.

Bowen, W.D., C.A. Beck, & D.A. Austin. (2002). Pinniped ecology. Pages 911-921 in W.F. Perrin, B. Würsig, & J.G.M. Thewissen, eds. *Encyclopedia of marine mammals*. San Diego: Academic Press.

Boyd, J., J. Craig, K. Rye, J. Sigurdson & R. Thrun. (2004). *Very shallow water explosion tests at Naval Amphibious Base, Coronado CA and San Clemente Island CA: Conditions, results, and model predictions*. (Technical Report prepared for the Navy Southwest Div.) 45 pp.

Brabyn, M.W. & I.G. McLean. (1992). Oceanography and Coastal Topography of Herd-Stranding Sites for Whales in New Zealand. *Journal of Mammalogy* 73:469-476.

Brabyn, M.W. & R.V.C. Frew. (1994). New Zealand Herd Stranding Sites Do Not Relate to Geomagnetic Topography. *Marine Mammal Science* 10:195-207.

Bradshaw, C.J.A., K, Evans, & M.A. Hindell. (2006). Mass Cetacean Strandings – a Plea for Empiricism. *Conservation Biology* 20:584-586.

Braun, R. (2005). Robert Braun, DVM., description of the Hanalei Bay melon-headed whale unusual event on 4 July, 2004, sent to Robert Brownell, NOAA-NMFS. Unpublished raw data.

Brodie, E.C., F.M.D. Gulland, D.J. Greig, M. Hunter, J. Jaakola, J. St. Leger, T.A. Leighfield, & F.M. Van Dolah. (2006). Domoic acid causes reproductive failure in California sea lions (*Zalophus californianus*). *Marine Mammal Science* 22:700–707.

Brownell, R.L., A.V. Yablokov, & V.A. Zemsky. (1998). *USSR pelagic catches of North Pacific sperm whales, 1949-1979: conservation implications*. Unpublished report submitted to International Whaling Commission. (SC/50/CAWS/27). 12 pp.

Brownell, R.L., P.J. Clapham, T. Miyashita, & T. Kasuya. (2001). Conservation status of North Pacific right whales. *Journal of Cetacean Research and Management, Special Issue* 2:269-286.

Brownell, R.L., T. Yamada, J.G. Mead, & A.L. van Helden, (2004). Mass strandings of Cuvier's beaked whales in Japan: U.S. Naval acoustic link Paper SC/56/E37 presented to the IWC Scientific Committee (unpublished). 10pp. Available from the *Office of the Journal of Cetacean Research and Management.*

Brownell, R.L., J.G. Mead, A.L. van Helden, A. Frantzis, & T.K. Yamada. (2006). Beaked whale mass strandings after 1961: Increasing evidence implicating anthropogenic sound. *Journal of Cetacean Research and Management.*

Buck, J.R. & P.L. Tyack. (2000). *Response of gray whales to low-frequency sounds*. 139th Meeting of the Acoustical Society of America, Atlanta, GA. June 2000.

Buckland, S.T., D.R. Anderson, K.P. Burnham, & J.L. Laake. (1993). *Distance sampling*. Chapman and Hall: London. 446 p.

Buckland, S.T., D.R Anderson, K.P Burnham, J.L. Laake, D. L. Borchers, & L. Thomas. (2001). *Introduction to Distance Sampling. Estimating Abundance of Biological Populations.* Oxford University Press: Oxford.

Budelmann, B.U. (1992a). *Hearing in crustacea. In: The Evolutionary Biology of Hearing.* D.B. Webster, R.R. Fay, & A.N. Popper (eds.), Spinger-Verlag: New York, NY Pp. 131-139.

Budelmann, B.U. (1992b). Hearing of nonarthropod invertebrates. In: Webster, D.B., Fay, R.R. and Popper, A.N. eds. *Comparative Evolutionary Biology of Hearing,* Springer Verlag, NY. Pp. 141-155.

Burgess, W.C., P.L. Tyack, B.J. Le Boeuf, & D.P. Costa. (1998). A programmable acoustic recording tag and first results from free-ranging northern elephant seals. *Deep-Sea Research II 45:1327-1351.*

Burtenshaw, J.C., E.M. Oleson, J.A. Hildebrand, M.A. McDonald, R.K. Andrew, B.M. Howe, & J.A. Mercer, 2004. Acoustic and satellite remote sensing of blue whale seasonality and habitat in the northeast Pacific. *Deep Sea Research II* 15:967-986.

Calambokidis, J. (1995). Blue whales off California. Whalewatcher, *Journal of the American Cetacean Society 29:3-7.*

Calambokidis, J., G.H. Steiger, J.C. Cubbage, K.C. Balcomb, C. Ewald, S. Kruse, R. Wells, & R. Sears. (1990). *Sightings and movements of blue whales off central California, 1986–88 from photo-identification of individuals.* (Reports of the International Whaling Commission, Special Issue 12:343-348).

Calambokidis, J., G.H. Steiger, J.M. Straley, T.J. Quinn II, L.M. Herman, S. Cerchio, D.R. Salden, M. Yamaguchi, F. Sato, J. Urban R., J.K. Jacobsen, O. Von Ziegesar, K.C. Balcomb, C.M. Gabrielle, M.E. Dahlheim, N. Higahsi, S. Uchida, J.K.B. Ford, Y. Miyamura, P.L. de Guevara P., S.A. Mizroch, L. Schlender, & K. Rasmussen. (1997). *Abundance and population structure of humpback whales in the North Pacific basin.* (Unpublished contract report to the National Marine Fisheries Service, La Jolla, California).

Calambokidis, J., G.H. Steiger, K. Rasmussen, J. Urbán R., K.C. Balcomb, P.L. de Guevara P., M. Salinas Z., J.K. Jacobsen, C.S. Baker, L.M. Herman, S. Cerchio, & J.D. Darling. (2000). Migratory destinations of humpback whales that feed off California, Oregon, and Washington. *Marine Ecology Progress Series* 192:295-304.

Calambokidis, J., G.H. Steiger, J.M. Straley, L.M. Herman, S. Cerchio, D.R. Salden, J.R. Urbán, J.K. Jacobsen, O. Von Ziegesar, K.C. Balcomb, C.M. Gabriele, M.E. Dahlheim, S. Uchida, G. Ellis, Y. Mlyamura, P. Ladrón de guevara, M. Yamaguchi, F. Sato, S.A. Mizroch, L. Schlender, K. Rasmussen, & J. Barlow. (2001). Movements and population structure of humpback whales in the North Pacific. *Marine Mammal Science* 17:769-794.

Calambokidis, J., T. Chandler, E. Falcone, & A. Douglas. (2004). *Research on large whales off California, Oregon, and Washington in 2003.* (Annual Report for 2003). Contract number

50ABNF100065. Prepared for Southwest Fisheries Science Center: La Jolla, California by Cascadia Research, Olympia, Washington.

Calambokidis, J., E.A. Falcone, T.J. Quinn, A.M. Burdin, P.J. Clapham, J.K.B. Ford, C.M. Gabriele, R. LeDuc, D. Mattila, L. Rojas-Bracho, J.M. Straley, B.L. Taylor, J. Urbán R., D. Weller, B.H. Witteveen, M. Yamaguchi, A. Bendlin, D. Camacho, K. Flynn, A. Havron, J. Huggins, & N. Maloney. (2008). *SPLASH: Structure of populations, levels of abundance and status of humpback whales in the North Pacific*. (Final report for Contract AB133F-03-RP-00078). Submitted to U.S. Dept of Commerce Western Administrative Center: Seattle, Washington. 57 pp.

Caldwell, D. K. & M. C. Caldwell. (1983). Whales and Dolphins. Pages 767-812. In: Alfred A. Knopf (ed.). *The Audubon Society Field Guide to North American Fishes, Whales and Dolphins.* Alfred A. Knopf, Inc., New York, NY.

Caldwell, D.K. & M.C. Caldwell. (1989). Pygmy sperm whale *Kogia breviceps* (de Blainville, 1838): Dwarf sperm whale *Kogia simus* Owen, 1866. Pages 253-260 in S.H. Ridgway and R. Harrison, eds. *Handbook of marine mammals. Volume 4: River dolphins and the larger toothed whales*. London: Academic Press.

Campagna, C., V. Falabella, & M. Lewis. (2007). Entanglement of southern elephant seals in squid fishing gear. *Marine Mammal Science* 23:414-418.

Capoulade, F. (2002). Whales and ferries in the Ligurian Sanctuary: captain's experience and owner's actions. *European Cetacean Society Newsletter* 40:18–25 (special issue).

Carder, D.A. & S. Ridgway. (1990). Auditory brainstem response in a neonatal sperm whale. *Journal of the Acoustical Society of America* 88: Supplement 1:S4

Carretta, J.V., J. Barlow, K.A. Forney, M.M. Muto, & J. Baker. (2001). *U.S. Pacific marine mammal stock assessments: 2001*. (NOAA Technical Memorandum NOAA-TM-NMFS-SWFWC-317).

Carretta, T. Price, D. Petersen, & R. Read. (2004). Estimates of marine mammal, sea turtle, and seabird mortality in the California drift gillnet fishery for swordfish and thresher shark, 1996-2002. *Marine Fisheries Review* 66:21-30.

Carretta, J.V., K.A. Forney, M.M. Muto, J. Barlow, J. Baker, B. Hanson, & M. Lowry. (2005). *U.S. Pacific marine mammal stock assessments: 2004*. (NOAA Technical Memorandum NMFS-SWFSC- 375:1-31 6).

Carretta, J.V., K.A. Forney, M.M. Muto, J. Barlow, J. Baker, B. Hanson, & M.S. Lowry. (2006). U.S. Pacific Marine Mammal Stock Assessments: 2005. U.S. Department of Commerce: NOAA-TM-NMFS-SWFSC–388.

Carretta, J.V., K.A. Forney, M.S. Lowry, J. Barlow, J. Baker, B. Hanson, & M.M. Muto. 2007. *U.S. Pacific Marine Mammal Stock Assessments: 2007.* US Department of Commerce, NOAA Technical Memorandum, NMFS-SWFSC-414. 320 pp.

Centers for Disease Control and Prevention. (2003). *Sixteenth Meeting of the Advisory Board on Radiation and Worker Health May 19-20, 2003*. Oak Ridge, Tennessee.

Cetacean and Turtle Assessment Program. (1982). *Characterization of marine mammals and turtles in the mid- and North Atlantic areas of the U.S. outer continental shelf*. (Final report to the U.S. Bureau of Land Management: Washington, D.C., from the Graduate School of Oceanography, University of Rhode Island, Kingston). NTIS PB83-215855.

Chambers, S. & R.N. James. (2005). *Sonar termination as a cause of mass cetacean strandings in Geographe Bay, south-western Australia*. Acoustics 2005, Acoustics in a Changing Environment. Proceedings of the Annual Conference of the Australian Acoustical Society, November 9 - 11, 2005, Busselton, Western Australia.

Charif, R.A., D.K. Mellinger, K.J. Dunsmore, K.M. Fristrup, & C.W. Clark. (2002). Estimated source levels of fin whale (*Balaenoptera physalus*) vocalizations: Adjustments for surface interference. *Marine Mammal Science* 18:81-98.

Cherfas, J. (1989). *The hunting of the whales*. Harmondsworth: Penguin.

Chivers, S.J., R.W. Baird, D.J. McSweeney, D.L. Webster, N.M Hedrick, & J.C. Salinas. (2007). Genetic variation and evidence for population structure in eastern North Pacific false killer whales (*Pseudorca crassidens)*. *Canadian Journal of Zoology* 85:783-794.

Christian, E.A. & J.B. Gaspin. (1974). *Swimmer Safe Standoffs from Underwater Explosions*. NSAP Project PHP-11-73: Naval Ordnance Laboratory. (Report NOLX-89, 1 July).

Clapham, P. J., L. S. Baraff, C. A. Carlson, M. A. Christian, D. K. Mattila, C. A. Mayo, M. A. Murphy, & S. Pittman, (1993). Seasonal occurrence and annual return of humpback whales, Megaptera novaeangliae, in the southern Gulf of Maine. *Canadian Journal of Zoology* 71:440-443.

Clapham, P.J., S. Leatherwood, I. Szczepaniak, & R.L. Brownell. (1997). Catches of humpback and other whales from shore stations at Moss Landing and Trinidad, California, 1919-1926. *Marine Mammal Science* 13:368-394.

Clapham, P.J. & J.G. Mead. (1999). Megaptera novaeangliae. *Mammalian Species* 604:1-9.

Clapham, P.J., C. Good, S.E. Quinn, R.R. Reeves, J.E. Scarff, & R.L. Brownell. (2004). Distribution of North Pacific right whales (*Eubalaena japonica*) as shown by 19th and 20th century whaling catch and sighting records. *Journal of Cetacean Research and Management* 6:1-6.

Clark, C.W. & R.A. Charif. (1998). *Acoustic monitoring of large whales to the west of Britain and Ireland using bottom-mounted hydrophone arrays, October 1996-September 1997*. JNCC Report 281: Joint Nature Conservation Committee, Aberdeen, UK.

Clark, C.W. & P.J. Clapham. (2004). *Acoustic monitoring on a humpback whale (Megaptera novaeangliae) feeding ground shows continual singing into late spring*. Proceedings of the Royal Society of London: Part B, 271:1051-1057.

Clark, C.W. & G.C. Gagnon. (2004). Low-frequency vocal behaviors of baleen whales in the North Atlantic: Insights from IUSS detections, locations and tracking from 1992 to 1996. *Journal of Underwater Acoustics* 52(3).

Clark, C.W. & K.M. Fristrup. (1997). Whales ‘95: A combined visual and acoustic survey of blue and fin whales off southern California. *Reports of the International Whaling Commission* 47:583-600.

Clark, C. W. & W. T. Ellison. (2004). Potential use of low-frequency sounds by baleen whales for probing the environment: Evidence from models and empirical measurements. Pages 564-582 in Thomas, J. A., C. F. Moss, & M. Vater, eds. *Echolocation in bats and dolphins*. Chicago, Illinois: University of Chicago Press.

Clarke, M.R. (1996). Cephalopods as prey. III. Cetaceans. *Philosophical Transactions of the Royal Society of London* 351:1053-1065.

Clyne, H. (1999). *Computer simulations of interactions between the North Atlantic right whale (Eubalaena glacialis) and shipping.*

Cockcroft, V.G., G. Cliff, & G.J.B. Ross. (1989). Shark predation on Indian Ocean bottlenose dolphins *Tursiops truncatus* off Natal, South Africa. *South African Journal of Zoology* 24:305-310.

Conner, R.C. (2000). Group living in whales and dolphins. IN: J. Mann, R.C. Conner, P.L. Tyack, & H. Whitehead, eds. *Cetacean Societies: Field Studies of Dolphins and Whales*. University of Chicago Press, Chicago. pp. 199-218.

Constantine, R., I. Visser, D. Buurman, R. Buurman, & B. McFadden. (1998). Killer whale (*Orcinus orca*) predation on dusky dolphins (*Lagenorhynchus obscurus*) in Kaikoura, New Zealand. *Marine Mammal Science* 14:324-330.

Cook, M.L:H., C.A. Manire, & D.A. Mann. (2005). Auditory evoked potential (AEP) measurements in stranded roughtoothed dolphins (Steno bredanensis). *Journal of the Acoustical Society of America* 17(4):2441.

Cook, M.L.H., R.A. Varela, J.D. Goldstein, S.D. McCulloch, G.D. Bossart, J.J. Finneran, D. Houser, & D.A. Mann. (2006). Beaked whale auditory evoked potential hearing measurements. *Journal of Comparative Physiology* A. 192:489–495.

Corkeron, P.J. & R.C. Connor. (1999). Why do baleen whales migrate? *Marine Mammal Science* 15:1228-1245.

Corkeron, P.J. & A.R. Martin. (2004). Ranging and diving behaviour of two ‘offshore’ bottlenose dolphins, *Tursiops sp*., off eastern Australia. *Journal of the Marine Biological Association of the United Kingdom* 84:465-468.

Corkeron, P.J. & S.M. Van Parijs. (2001). Vocalizations of eastern Australian Risso’s dolphins, *Grampus griseus*. *Canadian Journal of Zoology* 79:160-164.

Cox, T.M., T.J. Ragen, A.J. Read, E. Vos, R.W. Baird, K. Balcomb, J. Barlow, J. Caldwell, T. Ranford, L. Crum, A. D’amico, G. D’spain, A. Fernández, J. Finneran, R. Gentry, W. Gerth, F. Gulland, J. Hildebrand, D. Houser, T. Hullar, P.D. Jepson, D. Ketten, C.D. Macleod, P. Miller, S. Moore, D.C. Mountain., D. Palka:, P. Ponganis, S. Rommel, T. Rowles, B. Taylor, P. Tyack, D. Wartzok, R. Gisiner, J. Meads, & L. Benner. (2006). Understanding the impacts of anthropogenic sound on beaked whales. *Journal of Cetacean Research Management* 7:177–187.

Crocker, D.E., D.P. Costa, B.J. Le Boeuf, P.M. Webb, & D.S. Houser. (2006). Impacts of El Niño on the foraging behavior of female northern elephant seals. *Marine Ecology Progress Series* 309:1-10

Crocker, M.J. (1997). Editor, *Encyclopedia of Acoustics*, John Wiley and Sons, Inc., New York.

Crocker, M.J. & F. Jacobsen. (1997). Sound Intensity. In, Crocker, M.J. Editor, *Encyclopedia of Acoustics*. John Wiley and Sons, Inc., New York.

Croll, D.A., B.R. Tershy, A. Acevedo, & P. Levin. (1999). *Marine vertebrates and low frequency sound*. (Technical report for LFA EIS). Marine Mammal and Seabird Ecology Group, Institute of Marine Sciences: University of California at Santa Cruz.

Croll, D. A., B. R. Tershy, R. P.Croll, D.A., B.R. Tershy, R.P. Hewitt, D.A. Demer, P.C. Fiedler, S.E. Smith, W. Armstrong, J.M. Popp, T. Kiekhefer, V.R. Lopez, J. Urban, & D. Gendron. (1998). An integrated approach to the foraging ecology of marine birds and mammals. *Deep-Sea Research II* 45:1353-1371.

Croll, D.A., A. Acevedo-Gutiérrez, B.R. Tershy, & J. Urbán-Ramírez. (2001a). The diving behavior of blue and fin whales: Is dive duration shorter than expected based on oxygen stores? *Comparative Biochemistry and Physiology, Part A* 129:797-809.

Croll, D.A., C.W. Clark., J. Calambokidis., W.T. Ellison. & B.R. Tershy. (2001b). Effect of anthropogenic low-frequency noise on the foraging ecology of *Balaenoptera* whales. *Animal Conservation* 4:13-27.

Croll, D.A., C.W. Clark, A. Acevedo, B. Tershy, S. Flores, J. Gedamke, & J. Urban. (2002). Only male fin whales sing loud songs. *Nature* 417:809.

Crum, L.A. & Y. Mao. (1996). Acoustically enhanced bubble growth at low frequencies and its implications for human diver and marine mammal safety. *Journal of the Acoustical Society of America* 99:2898-2907.

Crum, L.A., M.R. Bailey, J. Guan, P.R. Hilmo, S.G. Kargl, T.J. Matula & O.A. Sapozhnikov. (2005). Monitoring bubble growth in supersaturated blood and tissue ex vivo and the relevance to marine mammal bioeffects. *Acoustics Research Letters Online* 6:214-220.

Culik, B.M. (2002). *Review on Small Cetaceans: Distribution, Behaviour, Migration and Threats, United Nations Environment Programme, Convention on Migratory Species*. Marine Mammal Action Plan/Regional Seas Reports and Studies. No. 177: 343 pp.

Cummings, W.C. (1985). Bryde's whale *Balaenoptera edeni* Anderson, 1878. Pages 137-154 in S.H. Ridgway and R. Harrison, eds. *Handbook of marine mammals. Volume 3: The sirenians and baleen whales*. San Diego: Academic Press.

Cummings, W.C. & P.O. Thompson. (1971). Underwater sounds from blue whale, *Balaenoptera musculus*. *Journal of the Acoustical Society of America* 50:1193-1198.

Curry, B.E. (1999). *Stress in mammals: The potential influence of fishery-induced stress on dolphins in the eastern tropical Pacific Ocean*. (NOAA Technical Memorandum NOAA-TMNMFS-SWFSC-260: 1-121).

Dahlheim, M.E., S. Leatherwood, & W.F. Perrin. (1982). *Distribution of killer whales in the warm temperate and tropical eastern Pacific*. (Reports of the International Whaling Commission 32:647-653).

Dahlheim, M.E. & J.E. Heyning. (1999). Killer whale *Orcinus orca* (Linnaeus, 1758). Pages 281-322 in S.H. Ridgway and R. Harrison, eds. *Handbook of marine mammals. Volume 6: The second book of dolphins and the porpoises.* San Diego: Academic Press.

Dailey, M.D. & W.A. Walker. (1978). Parasitism as a factor in single strandings of southern California cetaceans. *Journal of Parasitology* 64:593-596.

Dailey, M.D., M. Walsh, D. Odell & T. Campbell. (1991). Evidence of prenatal infection in the bottlenose dolphin. *Tursiops truncatus*) with the lungworm. *Halocercus lagenorhynchi*. Nematoda: Pseudaliidae. *Journal of Wildlife Diseases* 27:164-165.

Dalebout, M.L., G.J.B. Ross, C.S. Baker, R.C. Anderson, P.B. Best, V.G. Cockcroft, H.L. Hinsz, V. Peddemors, & R.L. Pitman. (2003). Appearance, distribution, and genetic distinctiveness of Longman's beaked whale, *Indopacetus pacificus*. *Marine Mammal Science* 9:421-461.

Dalecki, D., S.Z. Child, & C.H. Raeman. (2002). Lung damage from exposure to low-frequency underwater sound. *Journal of the Acoustical Society of America* 111:2462A.

D'Amico, A. & W. Verboom. (1998). *Report of the Bioacoustics Panel, NATO/SACLANT*. Pp. 2-1-2-60.

D'Amico, A., A. Bergamasco, P. Zanasca, S. Carniel, E Nancini, N. Portunato, V. Teloni, C, Mori, & R. Barbanti. (2003). Qualitative correlation of marine mammals with physical and biological parameters in the Ligurian Sea. *IEEE Journal of Oceanographic Engineering* 28:29-43.

Darling, J.D. & S. Cerchio. (1993). Movement of a humpback whale (*Megaptera novaeangliae*) between Japan and Hawaii. *Marine Mammal Science* 9:84-91.

Davis, P.Z.R. (2004). *Current status of knowledge of dugongs in Palau: A review and project summary report.* (The Nature Conservancy Pacific Islands Countries Report No. 7/04:1-39).

Davis, R.W., G.S. Fargion, N. May, T.D. Leming, M. Baumgartner, W.E. Evans, L.J. Hansen, & K. Mullin. (1998). Physical habitat of cetaceans along the continental slope in the north-central and western Gulf of Mexico. *Marine Mammal Science* 14:490-507.

Dean, F.C., C.M. Jurasz, V.P. Palmer, C.H. Curby, & D.L. Thomas. (1985). *Analysis of humpback , whale (Megaptera novaeangliae) blow interval data/Glacier Bay Alaska, 1976-1979.* (Report from the University of Alaska, Fairbanks, AK, for the U.S. National Park Service, Anchorage, AK, 224 pp).

Deeke, V.B. (2006). Studying marine mammal cognition in the wild: a review of four decades of playback experiments. *Aquatic Mammals* 32:461-482.

DeLong, R.L., G.L. Kooyman, W.G. Gilmartin, & T.R. Loughlin. (1984). Hawaiian monk seal diving behavior. *Acta Zoologica Fennica* 172: 129-1 31.

De Stephasis, R. & E. Urquiola. (2006). *Collisions between ships and cetaceans in Spain*. (Report to the Scientific Committee: International Whaling Commission). SC/58/BC5.

De Swart, R.L., T.C. Harder, P.S. Ross, H.W. Vos, & A.D.M.E. Osterhaus. (1995). Morbilliviruses and morbillivirus diseases of marine mammals. *Infectious Agents and Disease* 4:125-130.

Dierauf, L.A. & F.M.D. Gulland. (2001). Marine Mammal Unusual Mortality Events. In *Marine Mammal Medicine*, edited by L. A. Dierauf, & F. M. D. Gulland. CRC Press, Boca Raton. pp. 69-81.

Dietz, R., J. Teilmann, M.-P.H. Jørgensen, & M.V. Jensen. (2002). *Satellite tracking of humpback whales in West Greenland.* National Environmental Research Institute (Technical Report 411:1-38. Copenhagen, Denmark: National Environmental Research Institute).

Di Guardo, G. & G. Marruchella. (2005). Sonars, Gas Bubbles, and Cetacean Deaths. Letters to the Editor. *Veterinary Pathology* 42:517-518.

Dobson, A.J. (2002). *An introduction to generalized linear models*. Second Edition. Chapman and Hall, CRC Press. Boca Raton, Florida.

Dolar, M.L.L., W.A. Walker, G.L. Kooyman & W.F. Perrin. (2003). Comparative feeding ecology of spinner dolphins (*Stenella longirostris*) and Fraser's dolphins (*Lagenodelphis hosei*) in the Sulu Sea. *Marine Mammal Science* 19:1-19.

Dollar, S. & R. Grigg. (2004). Anthropogenic and natural stresses on selected coral reefs in Hawaii: A multi-decade synthesis of impact and recovery. *Pacific Science* 58:281-304.

Dolphin, W.F. (1987). Ventilation and dive patterns of humpback whales, *Megaptera novaeangliae*, on their Alaskan feeding grounds. *Canadian Journal of Zoology* 65:83-90.

Domingo, M., J. Visa, M. Pumarola, A. J. Marco, L. Ferrer, R. Rabanal, & S. Kennedy. (1992). Pathologic and immunocytochemical studies of morbillivirus infection in striped dolphins (*Stenella coeruleoalba*). *Veterinary Pathology* 29**:**1–10.

Domjan, M. (1998). *The Principles of Learning and Behavior*, 4th edition. Brooks-Cole Publishing, Pacific Grove.

Donaldson, T.J. (1983). Further investigations of the whales *Peponocephala electra* and *Globicephala macrorhynchus* reported from Guam. *Micronesica* 19:173-181.

Donovan, G.P. (1991). *A review of IWC stock boundaries*. (Reports of the International Whaling Commission, Special Issue: 13:39-63).

Dorne, J.L. & A.G. Renwick. (2005). The refinement of uncertainty/safety factors in risk assessment by the incorporation of data on toxicokinetic variability in humans. *Toxicological Sciences* 86:20-26.

Dorsey, E.M. (1983). Exclusive adjoining ranges in individually identified minke whales (*Balaenoptera acutorostrata*) in Washington state. *Canadian Journal of Zoology* 61:174-181.

Douglas, A.B., J. Calambokidis, S. Raverty, S.J. Jeffries, D.M. Lambourn, & S.A. Norman. (2008). Incidence of ship strikes of large whales in Washington State. *Journal of the Marine Biological Association of the United Kingdom*. 1-12.

D'Spain, G.L., A.D'Amico, & D.M. Fromm. (2006). Properties of the underwater sound fields during some well documented beaked whale mass stranding events. *Journal of Cetacean Research and Management* 7:223-238.

D'Vincent, C.G., R.M. Nilson, & R.E. Hanna. (1985). Vocalization and coordinated feeding behavior of the humpback whale in southeastern Alaska. *Scientific Reports of the Whales Research Institute* 36:41-47.

Dudok van Heel, W.H. (1966). *Navigation in cetacean, in Whales, Dolphins, and Porpoises.* edited by K. S. Norris (University of California Press, Berkeley), pp. 597-606.

Dufault, S., H. Whitehead, & M. C. Dillon. (1999). An examination of the current knowledge on the stock structure of sperm whales (*Physeter macrocephalus*). *Journal of Cetacean Research and Management* 1:1-10.

Dunn, J.L., J.D. Buck, & T.R. Robeck. (2001). Bacterial diseases of cetaceans and pinnipeds. *In Marine Mammal Medicine*, edited by L.A. Dierauf, & F.M.D. Gulland. CRC Press, Boca Raton, FL. Pp. 309-335.

Edds, P.L. (1982). Vocalizations of the blue whale, Balaenoptera musculus, in the St. Lawrence River. *Journal of Mammalogy* 63:345-347.

Edds, P.L., T.J. MacIntyre, & R. Naveen. (1984). Notes on a sei whale (*Balaenoptera borealis* Lesson) sighted off Maryland. *Cetus* 5:4–5.

Edds, P.L. (1988). Characteristics of finback Balaenoptera physalus vocalizations in the St. Lawrence Estuary. *Bioacoustics* 1:131-149.

Edds-Walton, P. L. (1997). Acoustic communication signals of mysticete whales. *Bioacoustics* 8:47-60.

Edds, P.L. & J.A.F. Macfarlane. (1987). Occurrence and general behavior of balaenopterid cetaceans summering in the St. Lawrence Estuary, Canada. *Bioacoustics* 1:131-149.

Eldredge, L.G. (1983). *Summary of environmental and fishing information on Guam and the Commonwealth of the Northern Mariana Islands: Historical background, description of the islands, and review of the climate, oceanography, and submarine topography*. (NOAA Technical Memorandum NMFS-SWFC-40:1-181).

Eldredge, LG. (1991). Annotated checklist of the marine mammals of Micronesia. *Micronesica* 24:217-230.

Eldredge, L.G. (2003). The marine reptiles and mammals of Guam. *Micronesica* 35-36:653-660.

Eliason, S.R. (1993). *Maximum likelihood estimation. Logic and practice*. SAGE Publications, Inc., Newbury Park, California.

Environmental Protection Agency. (1998). *Guidelines for ecological risk assessment*. Federal Register 63:26846 – 26924; OSHA occupational noise regulations at 29 CFR 1910.95.

Etnoyer, P., D. Canny, B.R. Mate, L.E. Morgan, J.G. Ortega-Ortiz & W.J. Nichols. (2006). Sea-surface temperature gradients across blue whale and sea turtle foraging trajectories off the Baja California Peninsula, Mexico. *Deep Sea Research Part II: Topical Studies in Oceanography* 53:340-358.

Evans, D.L. & G.R. England. (2001). *Bahamas Marine Mammal Stranding Event of 15-16 March 2000.* (Joint Interim Report). National Oceanic and Atmospheric Administration.

Evans, K., Thresher, R., Warneke, R.M., Bradshaw, C.J.A., Pook, M., Thiele, D., & Hindell, M.A. (2005). Periodic variability in cetacean strandings: links to large-scale climate events. *Biology Letters 1*; 147-150.

Evans, P.G.H. (2002). Habitat pressures. Pages 545-548 in W.F. Perrin, B. Würsig, & J.G.M. Thewissen,eds. *Encyclopedia of marine mammals*. San Diego: Academic Press.

Evans, P.G.H. & L.A. Miller. (2003). Proceedings of the Workshop on Active Sonar and Cetaceans, Las Palmas, Gran Canaria, 8 March 2003. *ECS Newsletter*. 42 (Special Issue)*:*78 pp.

Evans, P.G.H., Anderwald, P., & Baines, M.E. 2003. UK Cetacean Status Review. Final Report to English Nature & Countryside Council for Wales. *Sea Watch Foundation*, Oxford, UK. 150pp.

Evans, W. E. (1971). Orientation Behavior of Delphinids: Radio-telemetric Studies. In: *Orientation: Sensory Basis*, pp. 142-160, ed. H. E. Adler, Annals New York Acad. Sci., vol. 188.

Evans, W.E. (1994). Common dolphin, white-bellied porpoise *Delphinus delphis* Linnaeus, 1758. Pages 191-224 in S.H. Ridgway and R. Harrison, eds. *Handbook of marine mammals. Volume 5: The first book of dolphins.* San Diego: Academic Press.

Evans, P.G.H. & L.A. Miller. (2004). Proceedings of the Workshop on Active Sonar and Cetaceans. *European Cetacean Society Newsletter*. No. 42 Special Issue – February 2004.

Fahlman, A., A. Olszowka, B. Bostrom, & D. R. Jones. (2006). Deep diving mammals: dive behavior and circulatory adjustments contribute to bends avoidance. *Respiratory Physiology & Neurobiology* 153:66-77.

Fahy, F.J. (1995). *Sound Intensity*. E&FN Spon, London.

Fair, P.A. & P.R. Becker. (2000). Review of stress in marine mammals. *Journal of Aquatic Ecosystem Stress and Recovery* 7:335-354.

Feller, W. (1968). *Introduction to probability theory and its applicaton. Volume 1*. 3rd ed. John Wilay & Sons, NY, NY.

Farris, T. (2004). *Hawaiian Melon-headed Whale (Peponacephala electra)Mass Stranding Event of July 3-4, 2004.* (NOAA Technical Memorandum NMFS-OPR-31, April 2006).

Fay, R.R. (1988). *Hearing in vertebrates: a psychophysics data book*. Hill-Fay Associates, Winnetka, Illinois.

Ferguson, M.C. (2005). *Cetacean population density in the eastern Pacific Ocean: Analyzing patterns with predictive spatial models*. Ph.D. dissertation, University of California, San Diego.

Ferguson, M.C. & J. Barlow. (2001). *Spatial distribution and density of cetaceans in the eastern tropical Pacific Ocean based on summer/fall research vessel surveys in 1986-1996.* (Southwest Fisheries Science Center Administrative Report LJ-01-04. La Jolla, California: National Marine Fisheries Service).

Ferguson, M.C. & J. Barlow. (2003). *Addendum: Spatial Distribution and Density of Cetaceans in the Eastern Tropical Pacific Ocean based on summer/fall research vessel surveys in 1986-96.* (Administrative Report LJ-01-04, available from Southwest Fisheries Science Center, 8604 La Jolla Shores Dr., La Jolla, CA 92037).

Ferguson, M.C., J. Barlow, S.B. Reilly, & T. Gerrodette. (2006). Predicting Cuvier's (*Ziphius cavirostris*) and Mesoplodon beaked whale population density from habitat characteristics in the eastern tropical Pacific Ocean. *Journal of Cetacean Research and Management* 7:287-299.

Fernandez, A., J.F. Edwards, F. Rodriguez, A. Espinosa de los Monteros, P. Herraez, P. Castro, J.R. Jaber, V. Martin, & M. Arbelo. (2005). Gas and fat embolic syndrome Involving a mass stranding of beaked whales (Family Ziphiidae) exposed to anthropogenic sonar signals. *Veterinary Pathology* 42:446-457.

Ferrero, R.C., Hodder J, Cesarone J (1994) Recent strandings of rough-toothed dolphins (*Steno bredanensis*) on the Oregon and Washington coasts. Marine Mammal Science. 10:114-116.

Ferrero, R.C., S.E. Moore, & R.C. Hobbs. (2000). Development of beluga whale capture and satellite tagging protocol in Cook Inlet, Alaska. *Marine Fisheries Review* 62:112–123.

Fiedler, P.C. (2002). Ocean environment. Pages 824-830 in W.F. Perrin, B. Würsig, & J.G.M. Thewissen, eds. *Encyclopedia of marine mammals.* San Diego: Academic Press.

Finneran, J.J. & C.E. Schlundt. (2004). *Effects of intense pure tones on the behavior of trained odontocetes.* (Space and Naval Warfare Systems Center, San Diego, Technical Document).

Finneran, J.J., C.E. Schlundt, D.A. Carder, J.A. Clark, J.A. Young, J.B. Gaspin, & S.H. Ridgway. (2000). Auditory and behavioral responses of bottlenose dolphins (*Tursiops truncatus*) and a beluga whale (*Delphinapterus leucas*) to impulsive sounds resembling distant signatures of underwater explosions. *Journal of the Acoustical Society of America* 108:417-431.

Finneran, J.J., C.E. Schlundt, B. Branstetter, & R.L. Dear. (2007). Assessing temporary threshold shift in a bottlenose dolphin *(Tursiops truncates*) using multiple simultaneous auditory evoked potentials. *Journal of the Acoustical Society of America* 122, 1249-1264.

Finneran, J.J., D.A. Carder, & S.H. Ridgway. (2001). Temporary threshold shift (TTS) in bottlenose dolphins *Tursiops truncatus* exposed to tonal signals. *Journal of the Acoustical Society of America*. 1105:2749(A), 142nd Meeting of the Acoustical Society of America, Fort Lauderdale, FL. December.

Finneran, J.J., R. Dear, D.A. Carder, & S.H. Ridgway. (2002). Temporary shift in masked hearing thresholds in odontocetes after exposure to single underwater impulses from a seismic watergun. *Journal of the Acoustical Society of America* 111:2929-2940.

Finneran, J.J., C.E. Schlundt, D.A. Carder, & S.H. Ridgway. (2002). Auditory filter shapes for the bottlenose dolphin (*Tursiops truncatus*) and the white whale (*Delphinapterus leucas*) derived with notched noise. *Journal of the Acoustical Society of America* 112:7.

Finneran, J.J., D.A. Carder, & S.H. Ridgway. (2003). Temporary threshold shift measurements in bottlenose dolphins *Tursiops truncatus*, belugas *Delphinapterus leucas*, and California sea lions *Zalophus californianus*. *Environmental Consequences of Underwater Sound (ECOUS) Symposium:* San Antonio, TX, 12-16 May 2003.

Finneran, J.J. & C.E. Schlundt. (2004). *Effects of intense pure tones on the behavior of trained odontocetes.* TR 1913, February 2004. SPAWAR Systems Center (SSC), San Diego.

Finneran, J.J., D.A. Carder, C.E. Schlundt & S.H. Ridgway. (2005). Temporary threshold shift in bottlenose dolphins (*Tursiops truncatus*) exposed to mid-frequency tones. *Journal of Acoustical Society of America* 118:2696-2705.

Finneran, J.J. & D.S. Houser. (2006). Comparison of in-air evoked potential and underwater behavioral hearing thresholds in four bottlenose dolphins (*Tursiops truncatus*). *Journal of the Acoustical Society of America* 119:3181-3192.

Finney, D.J. (1971). *Probit Analysis, Third Edition*. London: Cambridge University Press.

Fish, J.F. & C.W. Turl. (1976). *Acoustic source levels of four species of small whales*. (Naval Undersea Center Report, NUC-TP 547).

Fletcher, S., B.J. Le Boeuf, D.P. Costa, P.L. Tyack, & S.B. Blackwell. (1996). Onboard acoustic recording from diving northern elephant seals. *Journal of the Acoustical Society of America* 100:2531-2539.

Flewelling, L.J., J.P. Naar, J.P. Abbott, D.G. Baden, N.B. Barros, G.D. Bossart, M.-Y.D. Bottein, D.G. Hammond, E.M. Haubold, C.A. Heil, M.S. Henry, H.M. Jacocks, T.A. Leighfield, R.H. Pierce, T.D. Pitchford, S.A. Rommel, P.S. Scott, K.A. Steidinger, E.W. Truby, F.M. Van Dolah, & J.H. Landsberg. (2005). Red tides and marine mammal mortalities. *Nature* 435:755-756.

Food and Drug Administration, U.S. Department of Agriculture, and Centers for Disease Control and Prevention. (2001). *Draft assessment of the relative risk to public health from foodborne Listeria monocytogenes among selected categories of ready-to-eat foods*. Food and Drug Administration, Center for Food Safety and Applied Nutrition; U.S. Department of Agriculture, Food Safety and Inspection Service; and Centers for Disease Control and Prevention. Rockville, Maryland and Washington, D.C.

Forcada, J. (2002). Distribution. Pages 327-333 in W.F. Perrin, B. Würsig, & J.G.M. Thewissen, eds. *Encyclopedia of marine mammals.* San Diego: Academic Press.

Ford, J.K.B. (2002). Killer whale *Orcinus orca*. Pages 669-676 in W.F. Perrin, B. Würsig, & J.G.M. Thewissen, eds. *Encyclopedia of marine mammals.* San Diego: Academic Press.

Forney, K.A. (2004). *Estimates of cetacean mortality and injury in two U.S. Pacific longline fisheries, 1994- 2002.* (Southwest Fisheries Science Center Administrative Report LJ-04-07). La Jolla, California: National Marine Fisheries Service.

Forney, K.A., D.J. St. Aubin & S.J. Chivers. (2002). *Chase encirclement stress studies on dolphins involved in eastern tropical Pacific Ocean purse-seine operations during 2001*. NMFS-SWFSC. (Administrative Report LJ-02-32). 27 pp.

Frankel, A.S. & C.W. Clark. (1998). Results of low frequency m sequence noise playbacks to humpback whales in Hawai'i. *Canadian Journal of Zoology* 76:521–535.

Frankel, A.S. & C.W. Clark. (2000). Behavioral responses of humpback whales (*Megaptera novaeangliae*) to full-scale ATOC signals. *Journal of the Acoustical Society of America* 108:1930-1937.

Frankel, A.S. & C.W. Clark. (2002a). Behavioral responses of humpback whales (*Megaptera novaeangliae*) to full-scale ATOC signals. *Journal of the Acoustical Society of America* 108:1930-1937.

Frankel, A.S. & C.W. Clark. (2002b). ATOC and other factors affecting the distribution and abundance of humpback whales (*Megaptera novaeangliae*) off the north shore of Kauai. *Marine Mammal Science* 18:644–662

Frantzis, A. (1998). Does acoustic testing strand whales? *Nature* 392:29.

Frantzis, A. (2004). The first mass stranding that was associated with the use of active sonar (Kyparissiakos Gulf, Greece, 1996). In: Proceedings of the workshop. Active sonar and cetaceans. 8 March 2003, Las Palmas, Gran Canaria. *ECS newsletter 42(Special Issue):*14 – 20.

Frazer, L.N. & E. Mercado. (2000). A Model for humpback whale sonar. IEEE. *Journal of Ocean Engineering* 25**:**160–182.

Freitas, L. (2004). The stranding of three Cuvier's beaked whales *Ziphius cavirostris* in Madeira archipelago – May 2000. *ECS Newsletter 42(Special Issue):*28 – 32.

Fromm, D. (2004a). *Acoustic Modeling Results of the Haro Strait For 5 May 2003*. Naval Research Laboratory Report: Office of Naval Research, 30 January 2004.

Fromm, D. (2004b). *EEEL Analysis of U.S.S. SHOUP Transmissions in the Haro Strait on 5 May 2003*. Naval Research Laboratory briefing of 2 September 2004.

Fujimori, L. (2002). *Elephant seal visits Hawaii shores: The young male is the first of its kind to be seen in the islands*. Honolulu Star-Bulletin News, 18 January.

Fujimori, L. (2005). *Seal steals the show on busy Waikiki Beach*. Honolulu Star-Bulletin News, 22 January.

Fulling, G.L., J.C. Cotton, J.A. Rivers, & P.H. Thorson. (2007). *Sei (Balaenoptera borealis) and Bryde's (B.edeni/brydei) whale co-occurrence in the Mariana Islands during the boreal winter*. Seventeenth Biennial Conference on the Biology of Marine Mammals. Cape Town, South Africa. 29 November to 3 December 2007.

Gabriele, C., A. Frankel, & T. Lewis, 2001. *Frequent humpback whale songs recorded in Glacier Bay, Alaska in Fall 2000.* Pages 77-78 in Abstracts, Fourteenth Biennial Conference on the Biology of Marine Mammals. November - 3 December 2001. Vancouver, British Columbia.

Gambell, R. (1979). *The Blue Whale. Biologist*. 26:209-215.

Gambell, R. (1985). Fin whale *Balaenoptera physalus* (Linneaus, 175 1 8). Pages 171-192 in Ridgway, S.H. and R. Harrison, eds. *Handbook of marine mammals. Volume 3: The sirenians and baleen whales.* San Diego, California: Academic Press.

Gannier, A. (2000). Distribution of cetaceans off the Society Islands (French Polynesia) as obtained from dedicated surveys. *Aquatic Mammals* 26:111-126.

Gannier, A. (2002). Cetaceans of the Marquesas Islands (French Polynesia): Distribution and relative abundance as obtained from a small boat dedicated survey. *Aquatic Mammals* 28:198-210.

Garrigue, C. & Greaves J. (2001). Cetacean records for the New Caledonian area. *Micronesica* 34: 27-33.

Gaskin, D.E. (1982). *The ecology of whales and dolphins*. Portsmouth, New Hampshire: Heinemann.

Gedamke, J., D.P. Costa, & A. Dunstan. (2001). Localization and visual verification of a complex minke whale vocalization. *Journal of the Acoustical Society of America* 109:3038-3047.

Geraci, J.R. & D.J. St. Aubin. (1987). Effects of parasites on marine mammals. *International Journal of Parasitology* 17:407-414.

Geraci, J.R. (1989). *Clinical investigation of the 1987-88 mass mortality of bottlenose dolphins along the U.S. central and south Atlantic coast.* (Final report to the National Marine Fisheries Service, U. S. Navy, Office of Naval Research, and Marine Mammal Commission: 63).

Geraci, J.R. & V.J. Lounsbury. (1993). *Marine Mammals Ashore: A Field Guide for Strandings*. Texas A&M University Sea Grant College Program. Galveston, TX.

Geraci, J.R., J. Harwood, & V.J. Lounsbury. (1999). Marine Mammal Die-Offs – Causes, Investigations, and Issues. *Conservation and Management of Marine Mammals*. Ed. J.R. Twiss and R.R. Reeves. Pp 367-395.

Geraci, J.R. & V.J. Lounsbury. (2005). *Marine Mammals Ashore: A Field Guide for Strandings.* Second Edition. National Aquarium in Baltimore, Baltimore, MD.

Gillespie, D. & R. Leaper. (2001). *Right whale acoustics: Practical applications in conservations.* (Workshop report). Yarmouth Port, Massachusetts: International Fund for Animal Welfare.

Gilmartin, M. & N. Revelante. (1974). The 'island mass' effect on the phytoplankton and primary production of the Hawaiian Islands. *Journal of Experimental Marine Biology and Ecology* 16:181- 204.

Gilmartin, W.G. & J. Forcada. (2002). Monk seals *Monachus monachus*, *M. tropicalis*, and *M. schauinslandi*. Pages 756-759 in W. F. Perrin, B. Wursig, & J.G.M. Thewissen, eds. *Encyclopedia of marine mammals.* San Diego: Academic Press.

Goddard, P. & D.J. Rugh. (1998). A group of right whales seen in the Bering Sea in July 1996. *Marine Mammal Science* 14:344-349.

Goertner, J.F. (1982). *Prediction of underwater explosion safe ranges for sea mammals*. NSWC/WOL TR-82-188. Naval Surface Weapons Center, White Oak Laboratory, Silver Spring, MD. 25 pp.

Goldbogen, J.A., J. Calambokidis, , R.E. Shadwick, E.M. Oleson, M.A. McDonald, & J.A Hildebrand. (2006). Kinematics of foraging dives and lunge-feeding in fin whales. The *Journal of Experimental Biology* 209:1231-1244.

Goldstein, T.2, J.A. K. Mazet, T.S. Zabka, G. Langlois, K.M. Colegrove, M. Silver, S. Bargu, F. Van Dolah, T. Leighfield, P.A. Conrad, J. Barakos, D.C. Williams, S. Dennison, M. Haulena, & F.M.D. Gulland. (2008). *Novel symptomatology and changing epidemiology of domoic acid toxicosis in California sea lions (Zalophus californianus): an increasing risk to marine mammal health*. Proceedings of the Royal Society B. 275:267–276.

Goodman-Lowe, G.D. (1998). Diet of the Hawaiian monk seal (*Monachus schauinslandi*) from the Northwestern Hawaiian Islands during 1991-1994. *Marine Biology* 132:535-546.

Goold, J.C. (2000). A diel pattern in vocal activity of short-beaked common dolphins, *Delphinus delphis*. *Marine Mammal Science* 16:240-244.

Goold, J.C. & S.E. Jones, S.E. (1995). Time and frequency domain characteristics of sperm whale clicks. *Journal of the Acoustical Society of America* 98:1279-1291.

Grachev, M.A. V.P. Kumarev, L.Mamaev, V.L. Zorin, L.V. Baranova, N.N. Denikina, S.I. Belikov, E.A. Petrov, V.S. Kolesnik, R.S. Kolesnik, V.M. Dorofeev, A.M.Beim, V.N. Kudelin, F.G. Nagieva, & V.N. Sidorov. (1989). Distemper virus in Baikal seals. *Nature*. 338:209.

Green, D.M. & J.A. Swets. (1974). *Signal Detection Theory and Psychophysics*. Robert E. Krieger Publishing, Huntington.

Gregr, E.J. & A.W. Trites. (2001). Predictions of critical habitat for five whales species in the waters of coastal British Columbia. *Canadian Journal of Fisheries and Aquatic Science* 58:1265-1285.

Greig, D.J., F.M.D. Gulland & C. Kreuder. (2005). A decade of live California sea lion. *Zalophus californianus*) strandings along the central California coast: Causes and trends, 1991-2000. *Aquatic Mammals* 31:11-22.

Guerra, A., A.F. González & F. Rocha. (2004). A review of the records of giant squid in the north-eastern Atlantic and severe injuries in *Architeuthis dux* stranded after acoustic explorations ICES Annual Science Conference 22–25 September 2004, Vigo, Spain. *ICES CM 2004 / CC: 29*.

Guinet, C, M.A. Lea, & S.D. Goldsworthy. (2000). Mass change in Antarctic fur seal (*Arctocephalus gazella*) pups in relation to maternal characterisitics at iles Kerguelen. *Canadian Journal of Zoology* 78:476–483

Gulland, F.M.D. (2006). *Review of the Marine Mammal Unusual Mortality Event Response Program of the National Marine Fisheries Service*. (Report to the Office of Protected Resources: NOAA/National Marine Fisheries Service, Silver Springs, MD. 32 pp).

Gulland, F.M.D., M. Koski, L.J. Lowenstine, A. Colagross, L. Morgan, & T. Spraker. (1996). Leptospirosis in California sea lions (*Zalophus californianus*) stranded in central California, 1981-1994. *Journal of Wildlife Diseases* 32:572-580.

Gulland, F.M.D. & A.J. Hall. (2005). The Role of Infectious Disease in Influencing Status and Trends. IN: J.E. Reynolds III, W.F. Perrin, R.R. Reeves, S. Montgomery, T.J. Ragen. *Marine Mammal Research*. John Hopkins University Press, Baltimore. pp. 47-61.

Gulland, F.M.D. & A.J. Hall. (2007). Is marine mammal health deteriorating? Trends in global reporting of marine mammal disease. *EcoHealth.* 4:135-150.

Gunther, E.R. (1949). The habits of fin whales. *Discovery Reports* 24:115-141.

Hain, J. H. W., M. A. M. Hyman, R. D. Kenney, & H. E. Winn, (1985). The role of cetaceans in the shelf-edge region of the northeastern United States. *Marine Fisheries Review* 47:13-17.

Hain, J. H. W., S. L. Ellis, R. D. Kenney, P. J. Clapham, B. K. Gray, M. T. Weinrich, & I. G. Babb, (1995). Apparent bottom feeding by humpback whales on Stellwagen Bank. *Marine Mammal Science* 11:464-479.

Haines, M.M., S.A. Stansfeld, J. Head, & R.F.S. Job. (2002). Multilevel modeling of aircraft noise on performance tests in schools around Heathrow Airport London. *Journal of Epidemiological and Community Health* 56:139-144.

Hamazaki, T, (2002). Spatiotemporal prediction models of cetacean habitats in the mid-western North Atlantic Ocean (from Cape Hatteras, North Carolina, U.S.A. to Nova Scotia, Canada). *Marine Mammal Science* 18:920-939.

Hanson, M.T. & R.H. Defran. (1993). The behavior and feeding ecology of the Pacific coast bottlenose dolphin, *Tursiops truncatus. Aquatic Mammals* 19:127-142.

Hardy, J.T. (1993). Phytoplankton. Pages 233-265 in M.D. Dailey, D.J. Reish, & J.W. Anderson, eds. *Ecology of the Southern California Bight*. Berkeley: University of California Press.

Harvell, C.D., K. Kim, J.M. Burkholder, R.R. Colwell, P.R. Epstein, D.J. Grimes, E.E. Hofmann, E.K. Lipp, A.D.M.E. Osterhaus, R.M. Overstreet, J.W. Porter, G.W. Smith, & G.R. Vasta. 1999. Emerging marine diseases-climate links and anthropogenic factors. *Science* 285:1505-1510.

Harwood, J. (2002). Mass Die-offs. In *Encyclopedia of Marine Mammals*, edited by W. F. Perrin, B. Würsig, & J. G. M. Thewissen. Academic Press, San Diego. Pp. 724-726.

Hastie, G.D., B. Wilson & P.M. Thompson. (2006). Diving deep in a foraging hotspot: acoustic insights into bottlenose dolphin dive depths and feeding behaviour. *Marine Biology* 148:1181-1188.

Heimlich, S.L., D.K. Mellinger, S.L. Nieukirk, & C.G. Fox. (2005). Types, distribution, and seasonal occurrence of sounds attributed to Bryde's whales (*Balaenoptera edeni*) recorded in the eastern tropical Pacific, 1999-2001. *Journal of the Acoustical Society of America* 118:1830-1837.

Heinze, G, & M. Schemper. (2002). A solution to the problem of separation in logistic regression. *Statistics in Medicine* 21:2409-2419.

Heithaus, M. R. (2001). Shark attacks on bottlenose dolphins (*Tursiops aduncus*) in Shark Bay, Western Australia:Attack rate, bite scar frequencies and attack seasonality. *Marine Mammal Science* 17:526-539.

Helweg, D.A., A.S. Frankel, J.R. Mobley, & L.H. Herman. (1992). Humpback whale song: Our current understanding. In J.A. Thomas, R.A. Kastelein and Y.A. Supin (eds.), *Marine mammal sensory systems*. Plenum, New York, NY. 773 pp.

Hennessy, J.W., J.P. Heybach, J. Vernikos, & S. Levine. (1979). Plasma corticosterone concentrations sensitively reflect levels of stimulus intensity in the rat. *Physiology and Behavior* 22:821-825.

Herman, L.M. & R.C. Antinoja. (1977). Humpback whales in Hawaiian waters: Population and pod characteristics. *Scientific Report of the Whales Research Institute* 29:59-85.

Herman, L.M., C.S. Baker, P.H. Forestell, & R.C. Antinoja. (1980). Right whale *Balaena glacialis* sightings near Hawaii: A clue to the wintering grounds? *Marine Ecology Progress Series* 2: 271-275.

Hersh, S.L. & D.A. Duffield. (1990). Distinction between northwest Atlantic offshore and coastal bottlenose dolphins based on hemoglobin profile and morphometry. Pages 129-139 in S. Leatherwood and R.R. Reeves, eds. *The bottlenose dolphin*. San Diego, California: Academic Press.

Herzing, D.L. (1996). Vocalizations and associated underwater behavior of free-ranging Atlantic spotted dolphins, *Stenella frontalis*. *Aquatic Mammals* 235:155-162.

Heyning, J.E. & T.D. Lewis. (1990). *Entanglements of baleen whales in fishing gear of southern California.* (Report International Whaling Commission, 40:427-431).

Heyning, J.E., & W.F. Perrin. (1994). Evidence for two species of common dolphins (genus *Delphinus*) from the eastern North Pacific. *Contributions in Science, Natural History Museum of Los Angeles County* 442:1-35.

Heyning, J.E. & J.G. Mead. (1996). Suction feeding in beaked whales: Morphological and observational evidence. *Contributions in Science, Natural History Museum of Los Angeles County 464:1-12.*

Hiby, A.R. & P.S. Hammond. (1989). *Survey techniques for estimating abundance of cetaceans*. (Report of the International Whaling Commission). Special Issue 11: 47-80.

Hickie, B.E., P.S. Ross, R.W. MacDonald & J.K.B. Ford. (2007). Killer whales (*Orcinus orca*) face protracted health risks associated with lifetime exposure to PCBs. *Environmental Science and Technology* 41:6613-6619.

Higgins, H.W. & D.J. Mackey. (2000). Algal class abundances, estimated from chlorophyll and carotenoid pigments, in the western Equatorial Pacific under El Niño and non-El Niño conditions. *Deep-Sea Research I* 47:1461-1483.

Hill, P.S. & D.P. DeMaster. (1998). *Alaska marine mammal stock assessments*. (U.S. Dep. Commerce, NOAA Technical Memorandum NMFS-AFSC-97). 166 p.

Hill, P.S. & D. P. DeMaster. (1999). *Alaska marine mammal stock assessments*. (U.S. Department of Commerce. NOAA Technical Memorandum. NMFS-AFSC-110). 166 pp.

Hill, P.S. & E. Mitchell. (1998). *Sperm whale interactions with longline vessels in Alaska waters during 1997*. Submitted to Fish. Bull., U.S. (Available upon request - P. S. Hill, Alaska Fisheries Science Center, 7600 Sand Point Way, NE, Seattle, WA 98115). Unpublished raw data.

Hiruki, L.M., M.K. Schwartz, & P.L. Boveng, (1999). Hunting and social behaviour of leopard seals (*Hydrurga leptonyx*) at Seal Island, South Shetland Islands, Antarctica. *Journal of Zoology* 249, 97-109.

Hoelzel, A.R. (2003). *Marine Mammal Biology: An Evolutionary Approach*. Blackwell Publishing, Malden MA.

Hoelzel, A.R., E.M. Dorsey, & S.J. Stern. (1989). The foraging specializations of individual minke whales. *Animal Behaviour* 38:786-794.

Hoffman, J.P. (2004). *Generalized linear models. An applied approach*. Pearson Education, Inc. Boston, Massachusetts.

Hohn, A.A., D.S. Rotstein, C.A. Harms, & B.L. Southall. (2006). *Report on marine mammal unusual mortality event UMESE0501Sp: Multispecies mass stranding of pilot whales (Globicephala macrorhynchus), minke whale (Balaenoptera acutorostrata), and dwarf sperm whales (Kogia sima) in North Carolina on 15-16 January 2005.* (NOAA Technical Memorandum NMFS-SEFSC-537, 222 pp).

Holt, R. & J. Powers. (1982). *Abundance estimation of dolphin stocks involved in the eastern tropical Pacific yellowfin tuna fishery determined from aerial and ship surveys to 1979.* (NOAA-TM-NMFS-SWFC- 23. 95 pp).

Hooker, S.K. & R.W. Baird. (1999). *Deep-diving behaviour of the northern bottlenose whale, Hyperoodon ampullatus (Cetacean: Ziphiidae).* Proceedings of the Royal Society, London B. 266:671-676.

Hooker, S.K., H. Whitehead, S. Gowans, & R.W. Baird. (2002). Fluctuations in distribution and patterns of individual range use of northern bottlenose whales. *Marine Ecology Progress Series* 225:287-297.

Horwood, J. (1987). *The sei whale: Population biology, ecology and management*. London: Croom Helm.

Horwood, J. (1990). *Biology and exploitation of the minke whale*. Boca Raton, Florida: CRC Press.

Hosmer, D.W. & S. Lemeshow. (2000). *Applied logistic regression*. Second Edition. John Wiley and Sons, Inc., New York, New York.

Houser, D.S., D.A. Helweg, & P.W.B. Moore. (2001a). A bandpass filter-bank model of auditory sensitivity in the humpback whale. *Aquatic Mammals* 27:82–91.

Houser, D. S., R. Howard, & S. Ridgway. (2001b). Can diving-induced tissue nitrogen supersaturation increase the chance of acoustically driven bubble growth in marine mammals? *Journal of Theoretical Biology* 213:183-195.

Houser, D. (2007). *Evaluation of Harbor Porpoise Behavioral Response Thresholds*. U.S. Navy Marine Mammal Program, SPAWAR Systems Center, San Diego.

Houser, D.S., A. Gomez-Rubio, & J.J. Finneran. (2008). Evoked potential audiometry of 13 Pacific bottlenose dolphins (*Tursiops truncates gilli*). *Marine Mammal Science* 24:28-41

Huber, H.R., A.C. Rovetta, L.A. Fry, & S. Johnston. (1991). Age-specific natality of northern elephant seals at the South Farallon Islands, California. *Journal of Mammalogy* 72:525-534.

International Council for the Exploration of the Sea. (2005). *Report for the Ad-hoc Group on Impacts of Sonar on Cetaceans and Fish (AGISC) CM 2006/ACE: 25 pp*.

International Council for the Exploration of the Sea. (2005b). *Answer to DG Environment request on scientific information concerning impact of sonar activities on cetacean populations 5 pp.*

International Whaling Commission. (2001). Report of the Workshop on the Comprehensive Assessment of Right Whales: A worldwide comparison. Journal of Cetacean Research and Management, Special Issue 2:1-60.

Ivashin, M.V. & L.M. Votrogov. (1981). Minke whales, Balaenoptera acutorostrata davidsoni, inhabiting inshore waters of the Chukotka coast. *Reports of the International Whaling Commission* 31:231.

Jansen, G. (1998). Physiological effects of noise. In *Handbook of Acoustical Measurements and Noise Control*, 3rd Edition. New York: Acoustical Society of America.

Jacquet, N., S. Dawson, & E. Slooten. (1998). *Diving behaviour of male sperm whales: foraging implications.* International Whaling Commission: Scientific Committee Doc. SC/50/CAWS 38, 20 pp.

Jacquet,. N., S. Dawson, & E. Slooten. (2000). Seasonal distribution and diving behaviour of male sperm whales off Kaikoura: Foraging implications. *Canadian Journal of Zoology* 78:407-419.

Jasny, M., J. Reynolds, C. Horowitz, & A. Wetzler. (2005). Sounding the Depths II: The rising toll of sonar, shipping, and industrial ocean noise on marine life. *Natural Resources Defense Council* 84 pp.

Jefferson, T.A., S. Leatherwood, & M.A. Webber. (1993). FAO species identification guide. *Marine mammals of the world*. Rome: Food and Agriculture Organization of the United Nations.

Jefferson, T.A. & S. Leatherwood. (1994). *Lagenodelphis hosei*. *Mammalian Species* 470:1-5.

Jefferson, T.A. & N.B. Barros. (1997). *Peponocephala electra*. *Mammalian Species* 553:1-6.

Jefferson, T.A., D. Fertl, M. Michael & T.D. Fagin. (2006). An unusual encounter with a mixed school of melon-headed whales (*Peponocephala electra*) and rough-toothed dolphin (*Steno bredanensis*) at Rota, Northern Mariana Islands. *Micronesica* 38:239-244.

Jensen, A. S. & G. K. Silber. (2004). *Large Whale Ship Strike Database*. (U. S. Department of Commerce, NOAA Technical Memorandum NMFS-OPR-25).

Jepson, P.D., M. Arbelo, R. Deaville, I.A.P. Patterson, P. Castro, J.R. Baker, E. Degollada, H.M. Ross, P. Herráez, A.M. Pocknell, F. Rodríguez, F.E. Howie, A. Espinosa, R.J. Reid, J.R. Jaber, V. Martin, A.A. Cunningham, & A. Fernández. (2003). Gas-bubble lesions in stranded cetaceans. *Nature* 425:575.

Jepson, P.D., R. Deaville, I.A.P. Patterson, A.M. Pocknell, H.M. Ross, J.R. Baker, F.E. Howie, R.J. Reid, A. Colloff, & A.A. Cunningham. (2005). Acute and Chronic Gas Bubble Lesions in Cetaceans Stranded in the United Kingdom. *Veterinary Pathology* 42:291-305.

Johnson, J.H. & T.H.Woodley. (1998). A survey of acoustic harassment device (AHD) use in the Bay of Fundy, NB, Canada. *Aquatic Mammals* 24:51-61.

Johnson, M., P.T. Madsen, W.M.X. Zimmer, N. Aguilar de Soto & P.L. Tyack. (2004). Foraging Blainville's beaked whales (*Mesoplodon densirostris*) produce distinct click types matched to different phases of echolocation. *Journal of Experimental Biology* 209:5038-5050.

Jones, D.M. & D.E. Broadbent. (1998). Chapter 24. Human performance and noise. Pages 24.21 - 24.24 In: C. M. Harris (ed.). *Handbook of acoustical measurements and noise control*. Acoustical Society of America: Woodbury, New York.

Jurasz, C.M. & V.P. Jurasz. (1979). Feeding modes of the humpback whale, *Megaptera novaeangliae*, in southeast Alaska. *Scientific Reports of the Whales Research Institute 31:69-83.*

Kami, H.T. & A.J. Hosmer. (1982). Recent beachings of whales on Guam. *Micronesica*18:133-135.

Kami, H.T. & R.J. Lujan. (1976). Records of the dwarf sperm whale *Kogia simus* Owen from Guam. *Micronesica* 12:327-332.

Kaminga, C. & J.G. van Velden. (1987). Investigations on cetacean sonar VIII/Sonar signals of *Pseudorca crassidens* in comparison with *Tursiops truncatus*. *Aquatic Mammals* 13:43–49.

Kastak, D. & R. J. Schusterman. (1996). Temporary threshold shift in a harbor seal (*Phoca vitulina*). *Journal of the Acoustical Society of America* 100:1905-1908.

Kastak, D. & R. J. Schusterman. (1998). Low-frequency amphibious hearing in pinnipeds: methods, measurements, noise, and ecology. *Journal of the Acoustical Society of America* 103:2216-2228.

Kastak, D. & R.J. Schusterman. (1999). In-air and underwater hearing sensitivity of a northern elephant seal (*Mirounga angustirostris*). *Canadian Journal of Zoology* 77:1751-1758.

Kastak, D., R.J. Schusterman, B.L. Southall, & C.J. Reichmuth. (1999a). Underwater temporary threshold shift induced by octave-band noise in three species of pinniped. *Journal of Acoustical Society of America* 106:1142-1148.

Kastak, D., R.J. Schusterman, B.L. Southall, & C.J. Reichmuth. (1999b). Underwater temporary threshold shift induced by octave-band noise in three species of pinniped. *Journal of the Acoustical Society of America* 106:1142-1148.

Kastak D., B.L. Southall, R.J. Schusterman, & C.R. Kastak. (2005). Underwater temporary threshold shift in pinnipeds: Effects of noise level and duration. *Journal of the Acoustical Society of America* 118:3154–3163.

Kastelein, R., M. Hagedoorn, W. W. L. Au, & D. De Haan, (2003). Audiogram of a striped dolphin (*Stenella coeruleoalba). Journal of the Acoustical Society of America* 113:1130-1137.

Kasuya, T. (1975). Past occurrence of *Globicephala melaena* in the western North Pacific. *Scientific Reports of the Whales Research Institute* 27:95-110.

Kasuya, T. (1991). Density-dependent growth in North Pacific sperm whales. *Marine Mammal Science* 7:230-257.

Kasuya, T. (2002). Giant beaked whales *Berardius bairdii* and *B. arnuxii*. Pages 519-522 in W.F. Perrin, B. Würsig, & J.G.M. Thewissen, eds. *Encyclopedia of marine mammals*. San Diego: Academic Press.

Kasuya, T., T. Miyashita, & F. Kasamatsu. (1988). Segregation of two forms of short-finned pilot whales off the Pacific Coast of Japan. *Scientific Reports of the Whales Research Institute* 39:77-90.

Kato, H. (2002). Bryde's whales *Balaenoptera edeni* and *B. brydei*. Pages 171 -176 in W.F. Perrin, B. Wursig, & J.G.M. Thewissen, eds. *Encyclopedia of Marine Mammals*. San Diego: Academic Press.

Katona, S.K. & S.D. Kraus. (1999). Efforts to conserve the North Atlantic right whale. In *Conservation and Management of Marine Mammals*, eds. J.R. Twiss, Jr. and R.R. Reeves, 311–331. Washington, DC: Smithsonian Institution Press.

Keeler, J.S. (1976). Models for noise-induced hearing loss. In *Effects of Noise on Hearing*, ed. Henderson et al., 361–381. New York: Raven Press.

Keenan, R.E. (2000). *An Introduction to GRAB Eigenrays and CASS Reverberation and Signal Excess.* Science Applications International Corporation, MA.

Kennett, J.P. (1982). *Marine geology*. Englewood Cliffs, New Jersey: Prentice-Hall, Inc.

Kennedy, S., T. Kuiken, P.D. Jepson, R. Deaville, M. Forsyth, T. Barrett, M.W.G. vande Bildt, A.D.M.E. Osterhaus, T. Eybatov, C. Duck, A. Kydyrmanov, I. Mitrofanov, & S. Wilson. (2000). Mass die-off of Caspian seals caused by canine distemper virus. *Emerging Infectious Diseases* 6:637-639.

Kenney, R.D. & H.E. Winn. (1987). Cetacean biomass densities near submarine canyons compared to adjacent shelf/slope areas. *Continental Shelf Research* 7:107-114.

Kenney, R.D., P.M. Payne, D.W. Heinemann, & H.E. Winn. (1996). Shifts in northeast shelf cetacean distributions relative to trends in Gulf of Maine/Georges Bank finfish abundance. Pages 169-196 in K. Sherman, N.A. Jaworski, & T.J. Smayda, eds. *The northeast shelf ecosystem: assessment, sustainability, and management.* Boston: Blackwell Science.

Kenney, R.D., G.P. Scott, T.J. Thompson, & H.E. Winn. (1997). Estimates of prey consumption and trophic impacts of cetaceans in the USA Northeast Continental Shelf ecosystem. *Journal of Northwest Atlantic Fishery Science* 22:155-171.

Ketten, D.R. (1992). The marine mammal ear: Specializations for aquatic audition and echolocation. Pages 717-750 in D. Webster, R. Fay, & A. Popper, eds. *The evolutionary biology of hearing*. Berlin: Springer-Verlag.

Ketten, D.R. (1997). Structure and functions in whale ears. *Bioacoustics* 8:103-135.

Ketten, D.R. (1998). *Marine mammal auditory systems: A summary of audiometric and anatomical data and its implications for underwater acoustic impacts*. (NOAA-TM-NMFS-SWFSC-256, Department of Commerce).

Ketten, D.R. (2000). Cetacean Ears. In: *Hearing by Whales and Dolphins*. Eds. W.W.L. Au, A.N. Popper, and R.R. Fay. Springer-Verlag, Inc., New York, NY. Pp 43-108.

Ketten, D.R. (2005). Annex K: Report of the standing working group on environmental concerns. Appendix 4. Marine mammal auditory systems: a summary of audiometric and anatomical data and implications for underwater acoustic impacts. *Journal of Cetacean Research and Management* 7:286-289.

Kinsey, D., P. Olson, & T. Gerrodette. (2000). *Marine mammal data collection* procedures on research ship line-transect surveys by the Southwest Fisheries Science Center. (SWFSC Administrative Report. LJ-00-08. 32p).

Kinsler, L.E. & A.R. Frey. (1962). *Fundamentals of Acoustics*. John Wiley and Sons, New York

Kirshvink, J.L. (1990). *Geomagnetic sensitivity in cetaceans: an update with live stranding records in the United States. Sensory Abilities of Cetaceans: Laboratory and Field Evidence*. Eds. J.A. Thomas and R.A. Kastelein. Plenum Press, NY. Pp 639-649.

Kirshvink, J.L., A.E. Dizon, & J.A. Westphal. (1986). Evidence from strandings for geomagnetic sensitivity in cetaceans. *Journal of Experimental Biology* 120:1-24.

Kishiro, T. (1996). *Movements of marked Bryde's whales in the western North Pacific*. (Reports of the International Whaling Commission. 46:421-428).

Kiyota, M., N. Baba, & M. Mouri. (1992). Occurrence of an elephant seal in Japan. *Marine Mammal Science* 8:433.

Klatsky, L.J., R.S. Wells, & J.C. Sweeney. (2007). Offshore bottlenose dolphins (*Tursiops truncatus*): movement and dive behavior near the bermuda pedestal. *Journal of Mammalogy* 88:59-66.

Klinowska, M. (1985). Cetacean stranding sites relate to geomagnetic topography. *Aquatic Mammals* 1:27-32.

Klinowska, M. (1986). Cetacean Live Stranding Dates Relate to Geomagnetic Disturbances. *Aquatic Mammals* 11:109-119.

Knowlton, A.R., C.W. Clark, & S.D. Kruse. (1991). *Sounds recorded in the presence of sei whales, Balaenoptera borealis.* Abstract. Ninth Biennial Conference on the Biology of Marine Mammals, Chicago, IL. pp. 76.

Knowlton, A.R., F.T. Korsmeyer, J.E. Kerwin, H.Y.Wu, & B. Hynes. (1995). *The hydrodynamic effects of large vessels on right whales.* (Final Report to NOAA Fisheries. NMFS Contract No. 40EANFF400534. 81 p).

Knowlton, A.R. & Kraus. S.D. (2001). Mortality and serious injury of northern right whales (Eubalaena glacialis) in the western North Atlantic Ocean. *Journal of Cetacean Research and Management (Special Issue)* 2:193-208.

Kompanje, E.J.O. (1995). *On the occurrence of spondylosis deformans in white-beaked dolphins Lagenorhynchus albirostris (Gray, 1846) stranded on the Dutch coast.* Zooligische Mededekingen Leiden. 69:231-250.

Kooyman, G.L., D.D. Hammond, & J.P. Schroeder. (1970). Brochograms and tracheograms of seals under pressure. *Science* 169:82-84.

Kooyman, G.L. & F. Trillmich. (1986). Diving behavior of Galapagos fur seals. IEn: Gentry, RL & GL Kooman (eds), *Fur seals: maternal strategies on land and at sea*, pp. 186-195. Princeton Univ. Press. USA.

Kooyman, G.L., R.W. Davis, & J.P. Croxall. (1986). Diving behavior of Antarctic fur seals. In: R.L. Gentry and G.L. Kooyman: *Fur seals - Maternal strategies on land and at sea*, pp.: 115-125, Princeton University Press.

Kopelman, A.H., & S.S. Sadove. (1995). Ventilatory rate differences between surface-feeding and nonsurface-feeding fin whales (*Balaenoptera physalus*) in the waters off eastern Long Island, New York, U.S.A., 1981-1987. *Marine Mammal Science* 11:200-208.

Krahn, M. M., M. J. Ford, W. F. Perrin, P. R. Wade, R. P. Angliss, M. B. Hanson, B. L. Taylor, G. M. Ylitalo, M. E. Dahlheim, J. E. Stein, & R. S. Waples. (2004). *2004 status review of southern resident killer whales (Orcinus orca) under the Endangered Species Act.* (NOAA Technical Memorandum NMFS-NWFSC-62:1-73).

Krausman, P.R., L.K. Harris, C.L. Blasch, K.K. G. Koenen, & J. Francine. (2004). Effects of military operations on behavior and hearing of endangered Sonoran pronghorn. *Wildlife Monographs* 1-41.

Krewski, D., C. Brown, & D. Murdoch. (1984). Determining "safe" levels of exposure: safety factors or mathematical models? *Toxicological Sciences* 4:383-394.

Krieger, K. J. & B. L. Wing. (1986). *Hydroacoustic monitoring ofprey to determine humpback whale movements.* (U.S. Department Commerce NOAA Techical Memorandum. NMFS FINWC-98. 62 pp).

Kruse, S., D.K. Caldwell, & M.C. Caldwell. (1999). Risso's dolphin *Grampus griseus* (G. Cuvier, 1812). Pages 183-212 in S.H. Ridgway and R. Harrison, eds. *Handbook of marine mammals. Volume 6: The second book of dolphins and the porpoises.* San Diego: Academic Press.

Kryter, K.D. W.D. Ward, J.D. Miller, & D.H. Eldredge. (1966). Hazardous exposure to intermittent and steady-state noise. *Journal of the Acoustical Society of America* 48:513-523.

Kryter, K.D. (1970). *The Effects of Noise on Man.* Academic Press, New York.

Kubota, G. (2004). *Sealing the attention*. Honolulu Star-Bulletin News, 28 December.

Lafortuna, C.L., M. Jahoda, A. Azzellino, F. Saibene, & A. Colombini. (2003). Locomotor behaviours and respiratory pattern of the Mediterranean fin whale (*Balaenoptera physalus*). *European Journal of Applied Physiology* 90:387-395.

Laist, D.W., A.R. Knowlton, J.G. Mead, A.S. Collet & M. Podesta. (2001). Collisions between ships and whales. *Marine Mammal Science* 17:35–75.

Lammers, M.O., W.W.L. Au, & D.L. Herzing. (2003). The broadband social acoustic signaling behavior of spinner and spotted dolphins. *Journal of the Acoustical Society of America* 114:1629-1639.

Lammers, M.O. (2004). Occurrence and behavior of Hawaiian spinner dolphins (*Stenella longirostris*) along Oahu's leeward and south shores. *Aquatic Mammals* 30:237-250.

Lagerquist, B.A., K.M. Stafford, & B.R. Mate. (2000). Dive characteristics of satellite-monitored blue whales (*Balaenoptera musculus*) off the central California coast. *Marine Mammal Science* 16:375-391.

Laurinolli, M.H., A.E. Hay, F. Desharnais, & C.T. Taggart. (2003). Localization of North Atlantic right whale sounds in the Bay of Fundy using a sonobuoy array. *Marine Mammal Science* 19:708-723.

Leatherwood, S. & R. R. Reeves. (1983). *The Sierra Club handbook of whales and dolphins*. San Francisco, California: Sierra Club Books.

Leatherwood, S. & R. Reeves. (1982). Pelagic Sightings of Risso's Dolphin, *Grampus griseus*, in the Gulf of Mexico and Atlantic Ocean Adjacent to Florida. *Journal of Mammalogy, Vol 63.*

Leatherwood, S., C. L. Hubbs, & M. Fisher. (1979). First records of Risso's dolphin (*Grampus griseus*) from the Gulf of California with detailed notes on a mass stranding. *Transactions of the San Diego Society of Natural History* 19:45-51.

Leatherwood, S., T.A. Jefferson, J.C. Norris, W.E. Stevens, L.J. Hansen, & K.D. Mullin. (1993). Occurrence and sounds of Fraser's dolphin (*Lagenodelphis hosei*) in the Gulf of Mexico. *Texas Journal of Science* 45:349-354.

Le Boeuf, B.J., R.J. Whiting, & R.F. Gannt. (1972). Perinatal behavior of northern elephant seal females and their young. *Behaviour* 43:121-156.

Le Boeuf, B.J. & L.F. Petrinovich. (1974). Dialects of northern elephant seals, *Mirounga angustirostris*: Origin and reliability. *Animal Behavior* 22:656-663.

Le Boeuf, B.J., Y. Naito, A.C. Huntley, & T. Asaga. (1989). Prolonged, continuous, deep diving by northern elephant seals. *Canadian Journal of Zoology* 67:2514-2519.

Le Boeuf, B.J. & J. Reiter. (1991). Biological effects associated with El Nino Southern Oscillation, 1982-83 on northern elephant seals breeding at Ano Nuevo, California. In: F. Trillmich and K.A. Ono, eds. *Pinnipeds and El Nino: Responses to Environmental Stress*. Springer-Verlag, Berlin. Pp. 206-218.

Le Boeuf, B.J., D.E. Crocker, D.P. Costa, S.B. Blackwell, P.M. Webb, & D.S. Houser. (2000). Foraging ecology of northern elephant seals. *Ecological Monographs* 70:353-382.

LeDuc, R.G., W.L. Perryman, Gilpatrick, Jr., J.W., J. Hyde, C. Stinchcomb, J.V. Carretta, & R.L. Brownell. (2001). A note on recent surveys for right whales in the southeastern Bering Sea. *Journal of Cetacean Research and Management, Special Issue* 2:287-289.

Lee, T. (1993). *Summary of cetacean survey data collected between the years of 1974 and 1985*. (NOAA Technical Memorandum NMFS-SWFSC-181. 85 pp).

Ligon, A.D. & R.W. Baird. (2001). *Diving behavior of false killer whales off Maui and Lana'i, Hawaii.* Abstract presented at 14th Biennial Conference on the Biology of Marine Mammals, Vancouver, Canada.

Liao, T.F. (1994). *Interpreting probability models. Logit, probit, and other generalized linear models.* SAGE Publications, Inc. Newbury Park, California.

Ljungblad, D.K., B. Würsig, S.L. Swartz, & J.M. Keene. (1988). Observations on the behavioral responses of Bowhead whales (*Balaena mysticetes*) to active geophysical vessels in the Alaskan Beaufort Sea. *Arctic* 41:183-194.

MacFarlane, J.A.F. (1981). *Reactions of whales to boat traffic in the area of the confluence of the Saguenay and St. Lawrence rivers, Quebec*. Manuscript cited in Richardson et al. 1995. 50 pp.

MacLeod, C.D. (1999). A review of beaked whale acoustics, with inferences on potential interactions with military activities. *European Research on Cetaceans* 13:35-38.

MacLeod, C.D. (2000). Review of the distribution of *Mesoplodon* species (Order Cetacea, Family Ziphiidae) in the North Atlantic. *Mammal Review* 30:1-8.

MacLeod, C.D., N. Hauser, & H. Peckham. (2004). Diversity, relative density and structure of the cetacean community in summer months east of Great Abaco, Bahamas. *Journal of the Marine Biological Association of the U.K.* 84:469-474.

Madsen, P.T., D.A. Carder, W.W.L. Au, P.E. Nachtigall, B. Møhl, & S.H. Ridgway. (2003). Sound production in neonate sperm whales (L). *Journal of the Acoustical Society of America* 113:2988-2991.

MacLeod, C.D., W.F. Perrin, R. Pittman, J. Barlow, L. Balance, A. D'Amico, T. Gerrodette, G. Joyce, K.D. Mullin, D.L. Palka, & G.T. Waring. (2006). Known and inferred distributions of beaked whale species (Cetacea: Ziphiidae). *Journal of Cetacean Research Management* 7:271-286.

Madsen, P.T., I. Kerr, & R. Payne. (2004). Echolocation clicks of tow free-ranging delphinids with different food preferences: false killer whales (*Pseudorca crassidens*) and Risso's dolphin (*Grampus griseus*). *Journal of Experimental Biology* 207:1811-1823.

Madsen, P.T., M.A. Johnson, P.J. Miller, A.N. Soto, J. Lynch, & P.L. Tyack. (2006). Quantitative measures of air-gun pulses recorded on sperm whales (*Physeter macrocephalus*) using acoustic tags during controlled exposure experiments. *Journal of the Acoustic Society of America* 120:2366-2379.

Magrab, E.B. (1975). *Environmental Noise Control*. John Wiley and Sons, New York

Maldini, D. (2003). *Abundance and distribution patterns of Hawaiian odontocetes: Focus on Oahu*. Ph.D dissertation, University of Hawaii, Manoa.

Maldini, D., L. Mazzuca & S. Atkinson. (2005). Odontocete Stranding Patterns in the Main Hawaiian Islands. 1937-2002: How Do They Compare with Live Animal Surveys? *Pacific Science* 59:55-67.

Malme, C.I., P.R. Miles, C.W. Clark, P. Tyack & J.E. Bird. (1983). *Investigations of the potential effects of underwater noise from petroleum industry activities on migrating gray whale behavior*. BBN Rep. 5366. Rep. from Bolt Beranek & Newman Inc., Cambridge, MA, for U.S. Minerals Management Service, Anchorage, AK. NTIS PB86-174174. Var.p.

Malme, C.I., P.R. Miles, C.W. Clark, P. Tyack & J.E. Bird. (1984). *Investigations of the potential effects of underwater noise from petroleum industry activities on migrating gray whale behavior/Phase II: January 1984 migration*. BBN Rep. 5586. (Report from Bolt Beranek & Newman Inc., Cambridge, MA, for U.S. Minerals Management Service, Anchorage, AK. NTIS PB86-218377).

Malme, C.I., B. Würsig, J.E. Bird, & P. Tyack. (1988). Observations of feeding gray whale responses to controlled industrial noise exposure. Pp. 55-73 in *Port and Ocean Engineering Under Arctic Conditions, Volume III* (W.M. Sackinger, M.O. Jeffries, J.L. Imm, & S.D. Treacy eds.) (University of Alaska, Fairbanks).

Marine Mammal Commission. (2003). Workshop on the management of Hawaiian monk seals on beaches in the Main Hawaiian Islands. Final report of a workshop held 29-31 October in Koloa, Kauai, Hawaii. Bethesda, Maryland: Marine Mammal Commission.

Marine Mammal Commission Advisory Committee on Acoustic Impacts on Marine Mammals. (2006). Report to the U.S. Marine Mammal Commission. Marine Mammal Commission; Bethesda, Maryland.

Marten, K. & S. Psarakos. (1999). Long-term site fidelity and possible long-term associations of wild spinner dolphins (*Stenella longirostris*) seen off Oahu, Hawaii. *Marine Mammal Science* 15:329-336.

Mate, B.R., S.L. Nieukirk, & S.D. Kraus. (1997). Satellite-monitored movements of the northern right whale. *Journal of Wildlife Management* 61:1393-1405.

Mate, B.R., B.A. Lagerquist, & J. Calambokidis. (1999). Movements of North Pacific blue whales during the feeding season off southern California and their southern fall migration. *Marine Mammal Science* 15:1246-1257.

Matthews, J.N., S. Brown, D. Gillespie, M. Johnson, R. McLanaghan, A. Moscrop, D. Nowacek, R. Leaper, T. Lewis, & P. Tyack. (2001). Vocalisation rates of the North Atlantic right whale (*Eubalaena glacialis*). *Journal of Cetacean Research and Management* 3:271-282.

Mattila, D.K., L.N. Guinee, & C.A. Mayo. (1987). Humpback whale songs on a North Atlantic feeding ground. *Journal of Mammalogy* 68:880-883.

May-Collado, L.J., I. Agnarsson, & D. Wartzok. (2007). Reexamining the relationship between body size and tonal signals frequency in whales: a comparative approach using a novel phylogeny. *Marine Mammal Science* 23:524-552.

Maybaum, H.L. (1989). *Effects of a 3.3 kHz sonar system on humpback whales, Megaptera novaeangliae, in Hawaiian waters*. M.S. Thesis, University of Hawaii, Manoa. 112 pp.

Maybaum, H.L. (1990). Effects of a 3.3 kHz sonar system on humpback whales, *Megaptera novaeangliae*, in Hawaiian waters. *Eos*. 71:92.

Maybaum, H.L. (1993). Responses of humpback whales to sonar sounds. *Journal of the Acoustical Society of America* 94:1848-1849.

Mazzuca, L., S. Atkinson, B. Keating, & E. Nitta. (1999). Cetacean mass strandings in the Hawaiian Archipelago, 1957-1998. *Aquatic Mammals* 25:105-114.

McAlpine, D.F. (2002). Pygmy and dwarf sperm whales Kogia breviceps and K. sima. Pages 1007-1009 in W.F. Perrin, B. Wursig, & J.G.M. Thewissen, eds. *Encyclopedia of Marine Mammals* San Diego: Academic Press.

McCullagh, P. & J.A. Nedler. (1989). *Generalized linear models*. Second Edition. Chapman and Hall; London, United Kingdom.

McCauley, R. D., J. Fewtrell, A.J. Duncan, C. Jenner, M.N. Jenner, J.D. Penrose, R.I. T. Prince, A. Adhitya, J. Murdock, & K. McCabe. (2000). *Marine seismic surveys: analysis and propagation of air-gun signals; and effects of air-gun exposure on humpback whales, sea turtles, fishes and squid*. (Report R99-15 prepared for Australian Petroleum Production Exploration Association).

McCulloch, C.E. & S.R. Searle. (2001). *Generalized, linear, and mixed models*. John Wiley and Sons, Inc.; New York, New York.

McCowan, B. & D. Reiss. (1995). Maternal aggressive contact vocalizations in captive bottlenose dolphins (*Tursiops truncatus*): Wide-band, low frequency signals during mother/aunt-infant interactions. *Zoo Biology* 14:293-309.

McDonald, M.A., J.A. Hildebrand, & Webb SC. (1995). Blue and fin whales observed on a seafloor array in the Northeast Pacific. *Journal of the Acoustical Society of America* 98:712–721.

McDonald, M.A., J.A. Hildebrand, S.M. Wiggins, D. Thiele, D. Glasgow, & S.E. Moore. (2005). Sei whale sounds recorded in the Antarctic. *Journal of the Acoustical Society of America* 118:3941-3945.

McDonald, M.A. & C.G. Fox. (1999). Passive acoustic methods applied to fin whale population density estimation. *Journal of the Acoustical Society of America* 105:2643-2651.

McDonald, M.A., J. Calambokidis, A.M. Teranishi, & J.A. Hildebrand. (2001). The acoustic calls of blue whales off California with gender data. *Journal of the Acoustical Society of America* 109:1728-1735.

McDonald, M.A. & S.E. Moore. (2002). Calls recorded from North Pacific right whales (*Eubalaena japonica*) in the eastern Bering Sea. *Journal of Cetacean Research and Management* 4:261-266.

McDonald, M.A., J.A. Hildebrand, & S.M. Wiggins. (2006). Increases in deep ocean ambient noise in the Northeast Pacific west of San Nicolas Island, California. *Journal of the Acoustical Society of America* 120:711-718.

McGrath, J.R. (1971). Scaling Laws for Underwater Exploding Wires. *Journal of the Acoustical Society of America* 50:1030-1033.

Mead, J.G. (1989). Beaked whales of the genus - *Mesoplodon*. Pages 349-430 in S.H. Ridgway and R. Harrison, eds. *Handbook of marine mammals. Volume 4: River dolphins and the larger toothed whales.* London: Academic Press.

Mellinger, D.K., C.D. Carson, & C.W. Clark. (2000). Characteristics of minke whale (*Balaenoptera acutorostrata*) pulse trains recorded near Puerto Rico. *Marine Mammal Science* 16:739-756.

Mellinger, D.K. & C.W. Clark. (2003). Blue whale (*Balaenoptera musculus*) sounds from the North Atlantic. *Journal of the Acoustical Society of America* 114:1108-1119.

Mellinger, D.K., K.M. Stafford, S.E. Moore, L. Munger, & C.G. Fox. (2004). Detection of North Pacific right whale (*Eubalaena japonica*) calls in the Gulf of Alaska. *Marine Mammal Science* 20:872-879.

Menard, S. (2000). Coefficients of determination for multiple logistic regression analysis. *The American Statistician* 54:17-24.

Menard, S. (2002). *Applied logistic regression analysis*. Second Edition. SAGE Publications, Inc., Newbury Park, California.

Mesnick, S.L., B.L. Taylor, B. Nachenberg, A. Rosenberg, S. Peterson, J. Hyde, & A.E. Dizon. (1999). Genetic relatedness within groups and the definition of sperm whale stock boundaries from the coastal waters off California, Oregon and Washington. Southwest Fisheries Center Administrative Report LJ-99-12:1-10. La Jolla, California: National Marine Fisheries Service.

McGraw-Hill Dictionary of Physics and Mathematics. (1978). D.N. Lapedes (Editor in Chief), McGraw-Hill Book Company, New York.

Miksis, J.L., Grund, M.D., Nowacek, D.P., Solow, A.R., Connor R.C. & Tyack, P.L. (2001). Cardiac Responses to Acoustic Playback Experiments in the Captive Bottlenose Dolphin, *Tursiops truncatus*. *Journal of Comparative Psychology* 115:227-232.

Miller, E.H. & D.A. Job. (1992). Airborne acoustic communication in the Hawaiian monk seal, *Monachus schauinslandi*. Pages 485-531 in J.A. Thomas, R.A. Kastelein and A.Y. Supin, eds. *Marine mammal sensory systems*. New York, New York. Plenum Press.

Miller, J.D., C.S. Watson, & W.P. Covell. (1963). *Deafening effects of noise on the cat.* Acta Oto-Laryngologica Supplement. 176:1–91.

Miller, J.D. (1974). Effects of noise on people. *Journal of the Acoustical Society of America* 56:729–764.

Miller, P.J.O., M.P. Johnson, & P.L. Tyack. (2004). *Sperm whale behaviour indicates the use of echolocation click buzzes 'creaks' in prey capture*. Proceedings of the Royal Society of London, Part B: 271:2239-2247.

Mills, J.H., R.M. Gilbert, & W.Y. Adkins. (1979). Temporary threshold shifts in humans exposed to octave bands of noise for 16 to 24 hours. *Journal of the Acoustical Society of America* 65:1238–1248.

Mitchell, E. (1975). Report of the meeting on smaller cetaceans, Montreal, April 1-11, 1974. Subcommittee on small cetaceans, Scientific Committee, International Whaling Commission. *Journal of the Fisheries Research Board of Canada* 32:889-983.

Miyashita, T. (1993). Abundance of dolphin stocks in the western North Pacific taken by the Japanese drive fishery. *Reports of the International Whaling Commission* 43:417-437.

Miyashita, T., H. Kato, & T. Kasuya. (1995). Worldwide map of cetacean distribution based on Japanese sighting data, Volume 1. Shimizu, Shizuoka, Japan: *National Research Institute of Far Seas Fisheries.*

Miyashita, T., T. Kishiro, N. Higash, F. Sato, K. Mori, & H. Kato. (1996). Winter distribution of cetaceans in the western North Pacific inferred from sighting cruises 1993-1995. *Reports of the International Whaling Commission* 46:437-441.

Miyazaki, N. & S. Wada. (1978). Observation of Cetacea during whale marking cruise in the western tropical Pacific. *Scientific Reports of the Whales Research Institute* 30:179-195.

Miyazaki, N. & W.F. Perrin. (1994). Rough-toothed dolphin-*Steno bredanensis* (Lesson, 1828). Pages 1-21 in S.H. Ridgway and R. Harrison, eds. *Handbook of marine mammals. Volume 5: The first book of dolphins.* San Diego, California: Academic Press.

Mizroch, S.A., D.W. Rice, D. Zwiefelhofer, J. Waite, & W.L. Perryman. (1999). *Distribution and movements of fin whales (Balaenoptera physalus) in the Pacific Ocean.* Page 127 in Abstracts, Thirteenth Biennial Conference on the Biology of Marine Mammals. 28 November-3 December 1999. Wailea, Maui.

Moberg, G.P. (2000). Biological response to stress: implications for animal welfare. Pages 1 - 21 In: G. P. Moberg, & J. A. Mench, editors. *The biology of animal stress. Basic principles and implications for animal welfare*. Oxford University Press, Oxford, United Kingdom.

Mobley, J.R. (2004). *Results of marine mammal surveys on U.S. Navy underwater ranges in Hawaii and Bahamas*. (Final Report to Office of Naval Research, 27 pp).

Mobley, J.R. (2005). *Results of 2005 Aerial Surveys of Humpback Whales North of Kauai*. (Report from Marine Mammal Research Consultants, Ltd. 15 pp).

Mobley, J.R. (2006). *Results of 2006 RIMPAC Aerial Surveys of Marine Mammals in Kaulakahi and Alenuihaha Channels*. (Final Report Submitted to Environmental Division Commander, U.S. Pacific Fleet. 12 pp).

Mobley, J.R., M. Smultea, T. Norris, & D. Weller. (1996). Fin whale sighting north of Kauai, Hawaii. *Pacific Science* 50:230-233.

Mobley, J.R., G.B. Bauer, & L.M. Herman. (1999). Changes over a ten-year interval in the distribution and relative abundance of humpback whales (*Megaptera novaeangliae*) wintering in Hawaiian waters. *Aquatic Mammals* 25:63-72.

Mobley, J.R., S.S. Spitz, K.A. Forney, R. Grotefendt, & P.H. Forestell. (2000). *Distribution and abundance of odontocete species in Hawaiian waters: Preliminary results of 1993-98 aerial surveys.* (Southwest Fisheries Science Center Administrative Report LJ-00-14C. La Jolla, California: National Marine Fisheries Service).

Mobley, J.R., S.S. Spitz, & R. Grotefendt. (2001a). *Abundance of humpback whales in Hawaiian waters: Results of 1993-2000 aerial surveys.* (Report prepared for the Hawaii Department of Land and Natural Resources and the Hawaiian Islands Humpback Whale National Marine Sanctuary, NOAA, U.S. Department of Commerce).

Mobley, J.R., L.L. Mazzuca, A.S. Craig, M.W. Newcomer, & S.S. Spitz. (2001b). Killer whales (*Orcinus orca*) sighted west of Niihau, Hawaii. *Pacific Science* 55:301-303.

Mobley, J.R., S.W. Martin, D. Fromm, & P.E. Nachtigall. (2007). *Lunar influences as possible cause for simultaneous aggregations of melon-headed whales in Hanalei Bay, Kauai and Sasanhaya Bay, Rota.* Seventeenth Biennial Confernce on the Biology of Marine Mammals. Cape Town, South Africa. 29 November to 3 December 2007.

Møhl, B., M. Wahlberg, P. T. Madesen, A. Heerfordt, & A. Lund. (2003). The monopulsed nature of sperm whale clicks. *Journal of the Acoustical Society of America* 114:1143-1154.

Moore, S.E., J.M. Waite, L.L. Mazzuca, & R.C. Hobbs. (2000). Mysticete whale abundance and observations of prey associations on the central Bering Sea shelf. *Journal of Cetacean Research and Management* 2:227-234.

Moore, S.E. & J.T. Clarke. (2002). Potential impact of offshore human activities on gray whales. *Eschrichtius robustus*. *Journal of Cetacean Research Management* 4:19-25.

Nachtigall, P.E., W.W.L. Au, J.L. Pawloski, & P.W.B. Moore. (1995). Risso's dolphin (*Grampus griseus*) hearing thresholds in Kaneohe Bay, Hawaii. Pages 49-53 in R.A. Kastelein, J.A. Thomas, & P.E. Nachtigall, eds. *Sensory systems of aquatic mammals*. Woerden, The Netherlands: De Spil Publishers.

Nachtigall, P.E., D.W. Lemonds, & H.L. Roitblat. (2000). *Psychoacoustic studies of dolphins and whales in Hearing by Dolphins and Whales.* W.W.L. Au, A.N. Popper, & R.R. Fay, eds. Springer, New York. Pp. 330-363.

Nachtigall, P.E., J.L. Pawloski, & W.W.L. Au. (2003). Temporary threshold shift and recovery following noise exposure in the Atlantic bottlenosed dolphin (*Tursiops truncatus*). *Journal of the Acoustical Society of America* 113:3425-3429.

Nachtigall, P.E., A. Supin, J.L. Pawloski, & W.W.L. Au. (2004). Temporary threshold shift after noise exposure in bottlenosed dolphin (*Tursiops truncatus*) measured using evoked auditory potential. *Marine Mammal Science* 20:673-687.

Nachtigall, P.E., M.M.L. Yuen, T.A. Mooney, & K.A. Taylor. (2005). Hearing measurements from a stranded infant Risso's dolphin, *Grampus griseus*. *The Journal of Experimental Biology* 208:4181-4188.

Nachtigall, P.E. & A.Y. Supin. (2008). A false killer whale adjusts its hearing when it echolocates. *Journal of Experimental Biology* 211:1714-1718.

National Marine Fisheries Service. (1988). *Critical habitat; Hawaiian monk seal; Endangered Species Act*. Federal Register. 53: 18,988-18,998.

National Marine Fisheries Service. (1998a). *Recovery plan for the blue whale (Balaenoptera musculus).* Prepared by R.R. Reeves, P.J. Clapham, R.L. Brownell, & G.K. Silber. Silver Spring, Maryland.

National Marine Fisheries Service. (1998b). *Draft recovery plan for the fin whale (Balaenoptera physalus) and sei whale (Balaenoptera borealis).* Prepared by R.R. Reeves, G.K. Silber, & P.M. Payne for the Office of Protected Resources, Silver Spring, Maryland. 47 pp.

National Marine Fisheries Service. (2001). *Interim Findings on the Stranding of Beaked Whales in the Bahamas – December 20,2001.* Retrieved January 24, 2007 from http://www.nmfs.noaa.gov/bahamasbeakedwhales.htm

National Marine Fisheries Service. (2002). *Endangered and threatened species: Determination on a petition to revise critical habitat for northern right whales in the Pacific*. Federal Register 67:7660-7665.

National Marine Fisheries Service. (2005). *Assessment of Acoustic Exposures on Marine Mammals in Conjunction with U.S.S. SHOUP Active Sonar Transmissions in the Eastern Strait of Juan de Fuca and Haro Strait, Washington, 5 May 2003.*

National Marine Fisheries Service. (2005b). *Pygmy Sperm Whale (Kogia breviceps): Western North Atlantic Stock.* (Stock Assessment Report. December, 2005).

National Marine Fisheries Service. (2005c). *Long-Finned Pilot Whale (Globicephala melas): Western North Atlantic Stock.* (Stock Assessment Report. December, 2005).

National Marine Fisheries Service. (2005d). *False Killer Whale (Pseudorca crassidens): Northern Gulf of Mexico Stock.* (Stock Assessment Report. December, 2005).

National Marine Fisheries Service. (2005e). *Dwarf Sperm Whale (Kogia sima): Western North Atlantic Stock.* (Stock Assessment Report. December, 2005).

National Marine Fisheries Service. (2005f). *Harbor Porpoise (Phocoena phocoena): Gulf of Maine/Bay of Fundy Stock.* (Stock Assessment Report. December, 2005).

National Marine Fisheries Service. (2005g). *Bottlenose Dolphin (Tursiops truncatus): Gulf of Mexico Bay, Sound, and Estuarine Stocks.* (Stock Assessment Report. December, 2005).

National Marine Fisheries Service. (2005h). Incidental Harassment Authorization for Conducting the Precision Strike Weapon (PSW) Testing and Training by Eglin Air Force Base. Federal Register 70, No. 160, 48675-48691.

National Marine Fisheries Service. (2006a). *Endangered and threatened species: Revision of critical habitat for the northern right whale in the Pacific Ocean*. Federal Register 71, No. 129, 38277-38297.

National Marine Fisheries Service. (2006b*). Final Rule, for Conducting the Precision Strike Weapon (PSW) Testing and Training by Eglin Air Force Base*. Federal Register 71, No. 226, 67810-67824.

National Marine Fisheries Service. (2006c). *Biennial Report to Congress on the Recovery Program for Threatened and Endangered Species- October 1, 2004 – September 30, 2006.* Office of Protected Resources: Silver Springs, MD. 185 pp.

National Marine Fisheries Service. (2007a). Retrieved January 29, 2007 from http://www.nmfs.noaa.gov/pr/pdfs/health/stranding_ fact_sheet.pdf

National Marine Fisheries Service. (2007b). Retrieved January 30, 2007 from http://www.nmfs.noaa.gov/pr/health/faq.htm

National Marine Fisheries Service. (2007c). Retrieved January 30, 2007 from http://www.nmfs.noaa.gov/pr/health/

National Marine Fisheries Service. (2007e). Retrieved February 2, 2007 from http://seahorse.nmfs.noaa.gov/msdbs/class/seahorse_ public.htm

National Marine Fisheries Service. (2007f). Office of Protected Resources. *Hawaii Viewing Guidelines*. Retrieved February 14, 2007 from http://www.nmfs.noaa.gov/pr/education/hawaii/guidelines.htm

National Marine Fisheries Service. (2007g). Retrieved January 31, 2007 from http://www.afsc.noaa.gov/NMML/education/cetaceans/ cetaceastrand.htm

National Marine Fisheries Service. (2007h). Office of Protected Resources. *2005 Multispecies Mass Stranding in North Carolina.* Retrieved February 16, 2007 from http://www.nmfs.noaa.gov/pr/health/mmume/event2005jan.htm

National Marine Fisheries Service. (2007i). *Multi-species Unusual Mortality Event in North Carolina Fact Sheet.* Retrieved February 26, 2007 from http://www.nmfs.noaa.gov/pr/pdfs/health/ume_jan_2005_fact_sheet.pdf

National Marine Fisheries Service. (2007j). Office of Protected Resources. *July 2004 mass Stranding of Melon-Headed Whales in Hawai'i*. Retrieved February 16, 2007 from http:www.nmfs.noaa.gov/pr/health/mmume/event2004jul.html

National Marine Fisheries Service. (2007k). *July 2004 Mass Stranding of Melon-Headed Whales in Hawai'i Fact Sheet for Final Report*. Retrieved February 16, 2007 from http://www.nmfs.noaa.gov /pr/pdfs/health/stranding_melonheadedwhales_july2004.pdf

National Marine Fisheries Service. (2007l). *Brevetoxin & Florida Red Tides*. Retrieved February 16, 2007 from http://www.nmfs.noaa.gov/pr/pdfs/health/brevetoxin.pdf

National Marine Fisheries Service. (2007m). *2004 Bottlenose Dolphin Unusual Mortality Event Along the Florida Panhandle*. Retrieved February 16, 2007 from http://www.nmfs.noaa.gov/pr/health/mmume/event2004.htm

National Marine Fisheries Service. (2007n). *STRANDINGS Newsletter of the Southeast United States Marine Mammal Health and Stranding Network. Winter 2006/Spring 2007*. (NOAA Tech Memo NMFS-SEFSC-545). Retrieved February 16, 2007 from http://www.sefsc.noaa.gov/PDFdocs/ SNewsletter112806 .pdf

National Marine Fisheries Service. (2008). *National Marine Fisheries Office of Protected Resources memorandum to Chief of Naval Operations Environmental Readiness*. 19 Jan 08.

National Oceanic and Atmospheric Administration. (2001). Final Rule for the Shock Trial of the WINSTON S. CHURCHILL (DDG-81. *Federal Register*. Department of Commerce: NMFS, FR 66, No. 87, 22450-67.

National Oceanic and Atmospheric Administration. (2002a). Final Rule SURTASS LFA Sonar. *Federal Register*. Department of Commerce; NMFS, FR 67, 136, 46712-89, 16 July.

National Oceanic and Atmospheric Administration. (2002b). *Report of the workshop on acoustic resonance as a source of tissue trauma in cetaceans*. NOAA Fisheries: Silver Spring, Maryland. April 2002.

National Oceanic and Atmospheric Administration. (2006a). *National Marine Fisheries Service Biological Opinion for RIMPAC, 2006.*

National Oceanic and Atmospheric Administration. (2006). NOAA Fisheries Service Releases Final Report on 2004 Stranding of Melon-headed Whales in Hawaii. *NOAA News* NOAA06-046, April 27, 2006.

National Oceanic and Atmospheric Administration. (2007). Taking and Importing Marine Mammals Incidental to the U.S. Navy Operations of Surveillance Towed Array Sensor System Low Frequency Active Sonar. *Federal Register.* Vol. 72, No. 161, pp. 46845-46893, 21 August 2007.

National Research Council. (2003). Ocean noise and marine mammals. *The National Academic Press.,* Washington D.C. 208 pp.

National Research Council. (2005). Marine Mammal Populations and Ocean Noise: Determining When Noise Causes Biologically Significant Effects. *The National Academic Press*. Washington D.C. 126 pp.

Nawojchik, R., D.J. St. Aubin & A. Johnson. (2003). Movements and dive behavior of two stranded, rehabilitated long-finned pilot whales (*Globicephala melas*) in the Northwest Atlantic. *Marine Mammal Science* 19:232-239.

Nedler, J.A. & T.W.M. Wedderburn. (1972). Generalized linear models. *Journal of the Royal Statistical Society, Series A* 135: 370 – 384.

Nedwell, J.R., B. Edwards, A.W.H. Turnpenny, & J. Gordon. (2004). *Fish and marine mammal audiograms: A summary of available information*. (Subacoustech Ltd. Report, Ref. 19534R0213).

Nemoto, T. & A. Kawamura. (1977). Characteristics of food habits and distribution of baleen whales with special reference to the abundance of North Pacific sei and Bryde's whales. *Reports of the International Whaling Commission, Special Issue* 1:80-87.

Norman, S.A. & J.G. Mead. (2001). *Mesoplodon europaeus*. *Mammalian Species* 688:1-5.

Norman, S.A., S. Raverty, W. McClellan, A. Pabst, D. Ketten, M. Fleetwood, J.K. Gaydos, B. Norberg, L. Barre, T. Cox, B. Hanson, & S. Jeffries. (2004). *Multidisciplinary investigation of stranded harbor porpoises (Phocoena phocoena) in Washington State with an assessment of acoustic trauma as a contributory factor (2 May – 2 June 2003).* (U.S. Department of Commerce: NOAA Tech Memo NMFS-North West Region-34. 120 pp).

Norris, K.S. & J.H. Prescott. (1961). Observations on Pacific cetaceans of Californian and Mexican waters. *University of California Publications in Zoology* 63:291-402.

Norris, K.S., B. Würsig, R.S. Wells, & M. Wursig. (1994). *The Hawaiian spinner dolphin*. Berkeley: University of California Press.

Norris, T.F., M.A. Smultea, A.M. Zoidis, S. Rankin, C. Loftus, C. Oedekoven, J.L. Hayes, & E. Silva. (2005). *A preliminary acoustic-visual survey of cetaceans in deep waters around Niihau, Kauai, and portions of Oahu, Hawaii from aboard the WV Dariabar, February 2005. (inal Technical and Cruise Report July 2005.* Prepared for Geo-Marine, Inc., Plano, Texas, and NAVFAC Pacific, Pearl Harbor, Hawaii, by Cetos Research Organization, Bar Harbor, Maine. Contract #2057sa05-F).

Northrop, J., W.C. Cummings, & M.F. Morrison. (1971). Underwater 20-Hz signals recorded near Midway Island. *Journal of the Acoustical Society of America* 49:1909-1910.

Northwest & Alaska Fisheries Center. (1978). *Northern elephant seal appears on one of the Northwestern Hawaiian Islands.*

Nowacek, D.P., M.P. Johnson, & P.L. Tyack. (2004). *North Atlantic right whales (Eubalaena glacialis) ignore ships but respond to alerting stimuli*. Proceedings of the Royal Society of London, part B. 271:227-231.

Nowacek, D.P., L.H. Thoren, D.W. Johnson & P.L. Tyack. (2007). Responses of cetaceans to anthropogenic noise. *Mammal Review* 37:81-115.

North Pacific Acoustic Laboratory. (2001). Office of Naval Research. *Final Environmental Impact Statement for the North Pacific Acoustic Laboratory. Volumes I and II, January 2001.*

Nuclear Regulatory Commission. (1997). *Proceedings of a dose-modeling workshop*. November 13 – 14, 1997. Washington, D.C.

Occupational Safety and Health Administration. (1996). Occupational noise exposure in OSHA safety and health standards 29 CFR 1910.95. *Federal Register*. 61. 9227, 7 March 1996.

Odell, D.K. & K.M. McClune. (1999). False killer whale *Pseudorca crassidens* (Owen, 1846). Pages 213-243 in S.H. Ridgway and R. Harrison, eds. *Handbook of marine mammals. Volume 6: The second book of dolphins and the porpoises.* San Diego: Academic Press.

Office of Naval Research Workshop. (1998). *Effects of Manmade Sound on the Marine Environment.* 10-12 February 1998, Bethesda, MD.

O'Hara, T.M. & C. Rice. (1996). Polychlorinated biphenyls. In: A. Fairbrother, L. Locke, & G Hoff (eds). *Noninfectious diseases of wildlife.* 2nd edition. Iowa State University Press, Ames, Iowa.

Ohizumi, H., T. Matsuishi, & H. Kishino. (2002). Winter sightings of humpback and Bryde's whales in tropical waters of the western and central and North Pacific. *Aquatic Mammals* 28:73-77.

Ohizumi, H., T. Isoda, T. Kishiro, & H. Kato. (2003). Feeding habits of Baird's beaked whale *Berardius bairdii*, in the western North Pacific and Sea of Okhotsk off Japan. *Fisheries Science* 69:11-20.

Ohsumi, S. & S. Wada. (1974). Status of whale stocks in the North Pacific, 1972. *Report of the International Whaling Commission* 25:114-126.

Okamura, H., K. Matsuoka, T. Hakamada, M. Okazaki, & T. Miyashita. (2001). Spatial and temporal structure of the western North Pacific minke whale distribution inferred from JARPN sightings data. *Journal of Cetacean Research and Management* 3:193-200.

Oleson, E., J. Barlow, C. Clark, J. Gordon, S. Rankin, & J. Hildebrand. (2003). Low frequency calls of Bryde's whales. *Marine Mammal Science* 19:407-419.

Oleson, E.M., J. Calambokidis, W.C. Burgess, M.A. McDonald, C.A. LeDuc, & J.A. Hildebrand, J.A. (2007). Behavioral context of call production by eastern North Pacific blue whales. *Marine Ecology Progress Series* 330: 269-284.

Omura, H., S. Ohsumi, T. Nemoto, K. Nasu, & T. Kasuya. (1969). Black right whales in the North Pacific. *Scientific Reports of the Whales Research Institute* 21:I-78.

Osborne, R. (2003). Historical Information on Porpoise Strandings in San Juan County Relative to the May 5th Navy Sonar Incident. *The Whale Museum News and Events.*

O'Shea, T.J. & R.L. Brownell. (1994). Organochlorine and metal contaminants in baleen whales: a review and evaluation of conservation implications. *Science of the Total Environment* 154:179-200.

Östman, J.S.O. (1994). *Social organization and social behavior of Hawaiian spinner dolphins (Stenella longirostris).* Ph.D dissertation., University of California at Santa Cruz.

Östman-Lind, J., A.D. Driscoll-Lind, & S.H. Rickards. (2004). *Delphinid abundance, distribution and habitat use off the western coast of the island of Hawaii.* (Southwest Fisheries Science Center Administrative Report LJ-04-02C. La Jolla, California: National Marine Fisheries Service).

Oswald, J.N., J. Barlow, & T.F. Norris. (2003). Acoustic identification of nine delphinid species in the eastern tropical Pacific Ocean. *Marine Mammal Science* 19:20-37.

Oswald, J.N., S. Rankin & J. Barlow. (2007). First description of whistles of Pacific Fraser's Dolphins *Lagenodelphis Hosei. Bioacoustics* 16:99-111.

Palacios, D.M. & B.R. Mate. (1996). Attack by false killer whales (*Pseudorca crassidens*) on sperm whales (*Physeter macrocephalus*) in the Galapagos Islands. *Marine Mammal Science* 12:582-587.

Pampel, F.C. (2000). *Logistic regression. A primer*. SAGE Publications, Inc. Newbury Park, California.

Panigada, S., M. Zanardelli, S. Canese, & M. Jahoda. (1999). Deep diving performances of Mediterranean fin whales. Page 144 in *Abstracts, Thirteenth Biennial Conference on the Biology of Marine Mammals*. 28 November-3 December 1999. Wailea, Maui.

Panigada, S., G. Pesante, M. Zanardelli & S. Oehen. (2003). *Day and night-time behaviour of fin whales in the western Ligurian Sea*. Proceedings of the Conference Oceans 2003, September 22-26, 2003, San Diego, CA. Pp 466-471.

Panigada, S., G. Pesante, M. Zanardelli, F. Capoulade, A. Gannier, & M.T. Weinrich. (2006). Mediterranean fin whales at risk from fatal ship strikes. *Marine Pollution Bulletin* 52:1287–1298

Parks, S.E., D.R. Ketten, J. Trehey O'Malley, & J. Arruda. (2004). Hearing in the North Atlantic right whale: Anatomical predictions. *Journal of the Acoustical Society of America* 115:2442.

Parrish, F.A., M.P. Craig, TJ. Regan, G.J. Marshall & B.M. Buhleier. (2000). Identifying diurnal foraging habitat of endangered Hawaiian monk seals using a seal-mounted video camera. *Marine Mammal Science* 18:244-258.

Parrish, F.A., K. Abernathy, G.J. Marshall, & B.M. Buhleier. (2002). Hawaiian monk seals (*Monachus schauinslandi*) foraging in deep-water coral beds. *Marine Mammal Science* 18:244-258.

Parrish, F.A., G.J. Marshall, C.L. Littnan, M. Heithaus, S. Canja, B. Becker, R. Braun, & G.A. Antonelis. (2005). Foraging of juvenile monk seals at French Frigate Shoals, Hawaii. *Marine Mammal Science* 21:93-107.

Payne, K., P. Tyack, & R. Payne. (1983). Progressive changes in the songs of humpback whales (*Megaptera novaengliae*): A detailed analysis of two seasons in Hawaii. Pp. 9-57 in R. Payne, ed. *Communication and behavior in whales*. Washington, D.C.: American Association for the Advancement of Science.

Payne, K. & R. Payne. (1985). Large scale changes over 19 years in songs of humpback whales in Bermuda. *Zeitschrift fur Tierpsychologie* 68:89-114.

Payne, P.M., J.R. Nicolas, L. O'Brien, & K.D. Powers. (1986). The distribution of the humpback whale, *Megaptera novaeangliae*, on Georges Bank and in the Gulf of Maine in relation to densities of the sand eel, *Ammodytes americanus*. *Fishery Bulletin* 84:271-277.

Perrin, W.F. & J. R. Geraci. (2002). Stranding. In W.F. Perrin, B. Würsig, & J.G.M. Thewissen, eds. *Encyclopedia of Marine Mammals*. San Diego, Academic Press: pp. 1192-1197.

Perrin, W.F. & J.W. Gilpatrick. (1994). Spinner dolphin--*Stenella longirostris* (Gray, 1828). Pages 99-128 in S.H. Ridgway and R. Harrison, eds. *Handbook of marine mammals. Volume 5: The first book of dolphins.* San Diego: Academic Press.

Perrin, W.F. & A.A. Hohn. (1994). Pantropical spotted dolphin. *Stenella attenuata*. Pages 71-98 in S.H. Ridgway and R. Harrison, eds. *Handbook of marine mammals. Volume 5: The first book of dolphins*. San Diego: Academic Press.

Perrin, W.F., C.E. Wilson, & F.I. Archer. (1994a). Striped dolphin. *Stenella coeruleoalba* (Meyen, 1833). Pages 129-159 in S.H. Ridgway and R. Harrison, eds. *Handbook of marine mammals. Volume 5: The first book of dolphins*. San Diego: Academic Press.

Perrin, W.F., S. Leatherwood, & A. Collet. (1994b). Fraser's dolphin-*Lagenodelphis hosei* (Fraser, 1956). Pages 225-240 in S.H. Ridgway and R. Harrison, eds. *Handbook of marine mammals. Volume 5: The first book of dolphins*. San Diego: Academic Press.

Perrin, W.F. & R.L. Brownell. (2002). Minke whales *Balaenoptera acutorostrata* and *B. bonaerensis*. Pages 750-754 in W.F. Perrin, B. Würsig, & J.G.M. Thewissen, eds. *Encyclopedia of marine mammals*. San Diego: Academic Press.

Perry, S.L., D.P. DeMaster, & G.K. Silber. (1999). The great whales: History and status of six species listed as endangered under the U.S. Endangered Species Act of 1973. *Marine Fisheries Review* 61:1-74.

Perryman, W.L. & T.C. Foster. (1980). *Preliminary report on predation by small whales, mainly the false killer whale, Pseudorca crassidens, on dolphins (Stenella spp. and Delphinus delphis) in the eastern tropical Pacific*. (Southwest Fisheries Science Center Administrative Report LJ-80-05. La Jolla, California: National Marine Fisheries Service).

Perryman, W.L., D.W.K. Au, S. Leatherwood, & T.A. Jefferson. (1994). Melon-headed whale. *Peponocephala electra* (Gray, 1846). Pages 363-386 in S.H. Ridgway and R. Harrison, eds. *Handbook of marine mammals. Volume 5: The first book of dolphins*. San Diego: Academic Press.

Philips, J.D., P.E. Nachtigall, W.W.L. Au, J.L. Pawloski, & H.L. Roitblat. (2003). Echolocation in the Risso's dolphin, *Grampus griseus*. *Journal of the Acoustical Society of America* 113:605-616.

Pianradosi, C.A. & E.D. Thalmann. (2004). Whales, sonar, and decompression sickness. *Nature* 15 April 2004.

Pickard, G.L. & W.J. Emery. (1982). *Descriptive physical oceanography: An introduction*. 4th ed. Oxford, United Kingdom: Pergamon Press.

Pickles, J.O. (1998). *An introduction to the physiology of hearing.* Academic Press, London. 367 pp.

Pierce, A.D. (1989). *Acoustics, An Introduction to Its Physical Principles and Applications, Acoustical Society of America*. Woodbury, NY.

Pike, G.C. & I.B. MacAskie. (1969). *Marine mammals of British Columbia.* Bulletin 171. Fisheries Research Board of Canada, Ottawa.

Pitman, R.L. (2002). Mesoplodont whales *Mesoplodon* spp. Pages 738-742 in W.F. Perrin, B. Würsig, & J.G.M. Thewissen, eds. *Encyclopedia of marine mammals*. San Diego: Academic Press.

Pitman, R.L., D.M. Palacios, P.L.R. Brennan, B.J. Brennan, K.C. Balcomb, & T. Miyashita. (1999). Sightings and possible identity of a bottlenose whale in the tropical Indo-Pacific: *Indopacetus pacificus*? *Marine Mammal Science* 15:531-549.

Pitman, R.L., L.T. Ballance, S.L. Mesnick, & S.J. Chivers. (2001). Killer whale predation on sperm whales: Observations and implications. *Marine Mammal Science* 17:494-507.

Pivorunas, A. (1979). The feeding mechanisms of baleen whales. *American Scientist* 67:432-440.

Podesta, M., A. D'Amico, G. Pavan, A. Drouga, A. Komnenou, & N. Portunato. (2006). A review of Ziphius cavirostris strandings in the Mediterranean Sea. *Journal of Cetacean Research and Mangagement* 7:251-261.

Polefka, S. (2004). *Anthropogenic Noise and the Channel Islands National Marine Sanctuary.* (Report by Environmental Defense Center, Santa Barbara, CA. 51 pp).

Poole, M.M. (1995). *Aspects of the behavioral ecology of spinner dolphins (Stenella longirostris) in the nearshore waters of Moorea, French Polynesia*. Ph.D. Dissertation., University of California, Santa Cruz.

Popov, V.V. & V.O. Klishin, (1998). EEG study of hearing in the common dolphin, *Delphinus delphis. Aquatic Mammals* 24:13-20.

Popper, A.N. (2008). *Effects of mid- and high-frequency sonars on fish.* (Report submitted to Naval Undersea Warfare Center Division, Newport, Rhode Island. Contract N66604-07m-6056. 53pp).

Popper, A.N., M. Salmon, & K.W. Horch. (2001). Acoustic detection and communication by decapod crustaceans. *Journal of Comparative Physiology* 187:83– 89.

Popper, A.N., M.B. Halvorsen, A. Kane, D.L. Miller, M.E. Smith, J. Song, P. Stein, & L.E. Wysocki. (2007). The effects of high intensity, low frequency active sonar on rainbow trout. *Journal of the Acoustical Society of America* 122:623-635.

Quaranta, A., P. Portalatini, & D. Henderson. (1998). Temporary and permanent threshold shift: An overview. *Scandinavian Audiology* 27:75–86.

Radenac, M. & M. Rodier. (1996). Nitrate and chlorophyll distributions in relation to thermohaline and current structures in the western tropical Pacific during 1985-1989. *Deep-Sea Research II* 43:725-752.

Ragen, T.J. & M.A. Finn. (1996). Chapter 8: The Hawaiian monk seal on Nihoa and Necker Islands, 1993. Pages 90-94 in T.C. Johanos and T.J. Ragen, eds. *The Hawaiian monk seal in the Northwestern Hawaiian Islands, 1993.* (NOAA Technical Memorandum NMFS-SWFSC 227:l-141).

Ragen, T.J. & D.M. Lavigne. (1999). The Hawaiian monk seal: Biology of an endangered species. Pages 224-245 in J.R. Twiss and R.R. Reeves, eds. *Conservation and Management of Marine Mammals*. Washington, D.C.: Smithsonian Institution Press.

Rankin, J.J. (1953). First record of the rare beaked whale, *Mesoplodon europaeus*, Gervais, from the West Indies. *Nature* 172: 873-874.

Rankin, S. & J. Barlow. (2003). Discovery of the minke whale "boing" vocalization, and implications for the seasonal distribution of the North Pacific minke whale. Page 134 in *Abstracts, Fifteenth Biennial Conference on the Biology of Marine Mammals*. 14–19 December 2003. Greensboro, North Carolina.

Rankin, S. & J. Barlow. (2007a). Vocalizations of the sei whale *Balaenoptera Borealis* off the Hawaiian Islands. *Bioacoustics* 16:137-145.

Rankin, S. & J. Barlow. (2007b). Sounds recorded in the presence of Blainville's beaked whales, *Mesoplodon densirostris*, near Hawai'i (L). *Journal of the Acoustical Society of America* 122:42-45.

Rankin, S., T.F. Norris, M.A. Smultea, C. Oedekoven, A.M. Zoidis, E. Silva, & J. Rivers. (2007). A Visual Sighting and Acoustic Detections of Minke Whales, *Balaenoptera acutorostrata* (Cetacea: Balaenopteridae), in Nearshore Hawaiian Waters. *Pacific Science* 61:3:395–398.

Read, A.J., P. Drinker, & S. Northridge. (2006). Bycatch of Marine Mammals in U.S. and Global Fisheries. *Conservation Biology* 20:63-169.

Redfern, J.V., M.C. Ferguson, E.A. Becker, K.D. Hyrenbach, C. Good, J. Barlow, K. Kaschner, M.F. Baumgartner, K.A. Forney, L.T. Ballance, P. Fauchald, P. Halpin, T. Hamazaki, A.J. Pershing, S. S. Qian, A. Read, S.B. Reilly, L. Torres, & F. Werner. (2006). Techniques for cetacean–habitat modeling. *Marine Ecology Progress Series* 310:271–295.

Reeder D.M. & K.M. Kramer. (2005). Stress in free-ranging mammals: integrating physiology, ecology, and natural history. Journal of Mammalogy 86:225-235.

Reeves, R.R., S. Leatherwood, G.S. Stone, & L.G. Eldredge. (1999). Marine mammals in the area served by the South Pacific Regional Environment Programme (SPREP). Apia, Samoa. *South Pacific Regional Environment Programme*.

Reeves, R.R., B.S. Stewart, P.J. Clapham, & J.A. Powell. (2002). *National Audubon Society guide to marine mammals of the world.* New York: Alfred A. Knopf.

Reeves, R.R., B.D. Smith, E.A. Crespo, & G. Notarbartolo di Sciara. (2003). *2002-2010 conservation plan for the world's cetaceans: Dolphins, whales, and porpoises*. Gland, Switzerland: IUCN.

Reeves, R.R., W.F. Perrin, B.L. Taylor, C.S. Baker, & S.L. Mesnick. (2004). *Report of the Workshop on Shortcomings of Cetacean Taxonomy in Relation to Needs of Conservation and Management, April 30 - May 2, 2004, La Jolla, California.* (NOAA Technical Memorandum NMFS-SWFSC 363:l-94).

Reijnders, P.J.H. & A. Aguilar. (2002). Pollution and Marine Mammals. In: W.F. Perrin, B. Würsig and J.G.M. Thewissen, *Encyclopedia of Marine Mammals*. Academic Press, San Diego, 948-956.

Reilly, S. (1990). Seasonal changes in distribution and habitat differences among dolphins in the eastern tropical Pacific. *Marine Ecology Progress Series* 66:1-11.

Reilly, S. & V.G. Thayer. (1990). Blue whale (*Balaenoptera musculus*) distribution in the eastern tropical Pacific. *Marine Mammal Science* 6:265-277.

Reilly, S.B. & P.C. Fiedler. (1994). Interannual variability of dolphin habitats in the eastern tropical Pacific. I: research vessel surveys, 1986 - 1990. *Fishery Bulletin* U.S. 92:434-450.

Rendell, L. & H. Whitehead. (2004). Do sperm whales share coda vocalizations? Insights into coda usage from acoustic size measurement. *Animal Behaviour* 67:865-874.

Rice, D.W. (1960). Distribution of the bottle-nosed dolphin in the Leeward Hawaiian Islands. *Journal of Mammalogy* 41:407-408.

Rice, D.W. (1977). Synopsis of biological data on the sei whale and Bryde's whale in the eastern North Pacific. *Reports of the International Whaling Commission, Special Issue* 1:92-97.

Rice, D.W. (1989). Sperm whale *Physeter macrocephalus* (Linnaeus, 1758). Pages 177-234 in S.H. Ridgway and R. Harrison, eds. *Handbook of marine mammals. Volume 4: River dolphins and the larger toothed whales.* San Diego: Academic Press.

Rice, D.W. (1998). Marine mammals of the world: Systematics and distribution. *Society for Marine Mammalogy Special Publication* 4:1-231.

Rice, D.W. & A.A. Wolman. (1971). The life history and ecology of the gray whale (*Eschrichtius robustus*). *American Society of Mammalogists, Special Publication* 3:1-142.

Richardson, W.J., C.R. Greene Jr., W.R. Koski, M.A. Smultea, G. Cameron, C. Holdsworth, G. Miller, T. Woodley, & B. Wursig. (1991). *Acoustic effects of oil production activities on bowhead and white whales visible during spring migration near Pt. Barrow, Alaska – 1990 phase*. (Report prepared by LGS Environmental Research Associates Ltd. for the U.S. Department of Interior, Minerals Management Service, Anchorage, Alaska. NTIS PB92-170430).

Richardson, W.J., C.R. Greene, Jr., C.I. Malme, & D.H. Thompson. (1995). *Marine mammals and noise.* San Diego: Academic Press, Inc.

Ridgway, S.H. & M.D. Dailey. (1972). Cerebral and cerebellar involvement of trematode parasites in dolphins and their possible role in stranding. *Journal of Wildlife Diseases* 8:33-43.

Ridgway, S.H. & R. Howard. (1979). Dolphin lung collapse and intramuscular circulation during free diving: evidence from nitrogen washout. *Science* 206:1182–1183.

Ridgway, S.H. (2000). The auditory central nervous system. Pages 273-293 in W.W.L. Au, A.N. Popper, & R.R. Fay, eds. *Hearing by whales and dolphins*. New York: Springer-Verlag.

Ridgway, S.H., B.L. Scronce, & J. Kanwisher. (1969). Respiration and deep diving in the bottlenose porpoise. *Science* 166:1651-1654.

Ridgway, S.H., D.A. Carder, R.R. Smith, T. Kamolnick, C.E. Schlundt, & W.R. Elsberry. (1997). *Behavioral responses and temporary shift in masked hearing threshold of bottlenose dolphins, Tursiops truncatus, to 1-second tones of 141 to 201 dB re 1 µPa*. Technical Report 1751, Revision 1. San Diego: Naval Sea Systems Command.

Ridgway, S.H. & D.A. Carder. (2001). Assessing hearing and sound production in cetaceans not available for behavioral audiograms: Experiences with sperm, pygmy sperm, and gray whales. *Aquatic Mammals* 27:267-276.

Ridgway, S., D. Carder, J. Finneran, M. Keogh, T. Kamolnick, M. Todd, & A. Goldblatt. (2006). Dolphin continuous auditory vigilance for five days. *Journal of Experimental Biology* 209:3621-3628

Rivers, J.A. (1997). Blue whale, *Balaenoptera musculus*, vocalizations from the waters off central California. *Marine Mammal Science* 13:186-195.

Rivers, J.A., G.L. Fulling, P. Thorson, & C. Oedekoven. (2007). *Humpback whale (Megaptera novaengliae) fluke photographs from the Northern Mariana Islands compared with other geographic areas.* Seventeenth Biennial Confernce on the Biology of Marine Mammals. Cape Town, South Africa. 29 November to 3 December 2007.

Robertson, K.M. & S.J. Chivers. (1997). Prey occurrence in pantropical spotted dolphins, *Stenella attenuata*, from the eastern tropical Pacific. *Fishery Bulletin* 95:334-348.

Roden, C. L. & K. D. Mullin. (2000). Sightings of cetaceans in the northern Caribbean Sea and adjacent waters, winter 1995. *Caribbean Journal of Science* 36:280-288.

Rogers, A.D. (1994). The biology of seamounts. Pages 306-350 in J.H. Blaxter, and A.J. Southward, eds. *Advances in marine biology*. San Diego: Academic Press.

Romano, T.A., J.A. Olschowka, S.Y. Felten, V. Quaranta, S.H. Ridgway, & D.L. Felten. (2002). Immune response, stress, and environment: Implications for cetaceans. In: *Cell and Molecular Biology of Marine Mammals.* C.J. Pfeiffer (ed). Krieger Publishing Co., Inc. pp. 53-279.

Romano, T.A., M.J. Keogh, C. Kelly, P. Feng, L. Berk, C.E. Schlundt, D.A. Carder, & J.J. Finneran. (2004). Anthropogenic sound and marine mammal health: measures of the nervous and immune systems before and after intense sound exposure. *Canadian Journal of Fisheries and Aquatic Science* 61:1124-1134.

Rosenbaum, H.C., R.L. Brownell, M.W. Brown, C. Schaeff, V. Portway, B.N. Whiate, S. Malik, L.A. Pastene, N.J. Patenaude, C.S. Baker, M. Goto, P.B. Best, P.J. Clapham, P. Hamilton, M. Moore, R. Payne, V. Rowntree, C.T. Tynan, J.L. Bannister, & R. DeSalle. (2000). World-wide genetic differentiation of *Eubalaena*: Questioning the number of right whale species. *Molecular Ecology* 9:1793-1802.

Rosenbaum, H.C., M. Egan, P.J. Clapham, R.L. Brownell, S. Malik, M.W. Brown, B.N. White, P. Walsh, & R. DeSalle. (2000). Utility of North Atlantic right whale museum specimens for assessing changes in genetic diversity. *Conservation Biology* 14:1837-1842.

Ross, D. (1976). *Mechanics of underwater noise*. Pergamon, New York. 375 pp.

Ross, D. (1987). *Mechanics of Underwater Noise*. Peninsula Publishing, Los Altos, CA.

Ross, G.J.B. & S. Leatherwood. (1994). Pygmy killer whale. *Feresa attenuata* Gray, 1874. Pages 387-404 in S.H. Ridgway and R. Harrison, eds. *Handbook of marine mammals. Volume 5: The first book of dolphins.* San Diego: Academic Press.

Rowntree, V., J. Darling, G. Silber, & M. Ferrari. (1980). Rare sighting of a right whale (*Eubalaena glacialis*) in Hawaii. *Canadian Journal of Zoology* 58:309-312.

Salden, D.R. (1988). Humpback whale encounter rates offshore of Maui, Hawaii. *Journal of Wildlife Management* 52:301-304.

Salden, D.R. (1989). An observation of apparent feeding by a sub-adult humpback whale off Maui, Hawaii. Page 58 in *Abstracts, Eighth Biennial Conference on the Biology of Marine Mammals.* 7-11 December 1989. Pacific Grove, California.

Salden, D.R. & J. Mickelsen. (1999). Rare sighting of a North Pacific right whale (*Eubalaena glacialis*) in Hawaii. *Pacific Science* 53:341-345.

Salden, D.R., L.M. Herman, M. Yamaguchi, & F. Sato. (1999). Multiple visits of individual humpback whales (*Megaptera novaeangliae*) between the Hawaiian and Japanese winter grounds. *Canadian Journal of Zoology* 77:504-508.

Sanvito, S. & F. Galimberti. (2003). Source level of male vocalizations in the genus *Mirounga*: Repeatability and correlates. *Bioacoustics* 14:47-59.

Sapolsky, R.M. (2005). The influence of social hierarchy on primate health. *Science* 308: 648-652.

Saunders, J.C., J.H. Mills, & J.D. Miller. (1977). Threshold shift in the chinchilla from daily exposure to noise for six hours. *Journal of the Acoustical Society of America* 61:558–570.

Scarff, J.E. (1986). Historic and present distribution of the right whale (*Eubalaena glacialis*) in the eastern North Pacific south of 50°N and east of 180°W. *Reports of the International Whaling Commission, Special Issue* 10:43-63.

Scarff, J.E. (1991). Historic distribution and abundance of the right whale (*Eubalaena glacialis*) in the North Pacific, Bering Sea, Sea of Okhotsk and Sea of Japan from the Maury Whale Charts. *Reports of the International Whaling Commission* 41:467-489.

Schilling, M.R., I. Seipt, M.T. Weinrich, S.E. Frohock, A.E. Kuhlberg, & P.J. Clapham. (1992). Behavior of individually-identified sei whales *Balaenoptera borealis* during an episodic influx into the southern Gulf of Maine in 1986. *Fishery Bulletin* 90:749-755.

Schlundt, C.E., J.J. Finneran, D.A. Carder, & S.H. Ridgway. (2000). Temporary shift in masked hearing thresholds of bottlenose dolphins, *Tursiops truncatus*, and white whales, *Delphinapterous leucas*, after exposure to intense tones. *Journal of the Acoustical Society of America* 107: 3496-3508.

Schlundt, C.E., R.L. Dear, D.A. Carder, & J.J. Finneran. (2006). Growth and recovery of temporary threshold shifts in a dolphin exposed to mid-frequency tones with durations up to 128 s. Journal of the Acoustical Society of America. 120:3227A.

Schlundt, C.E., R.L. Dear, L. Green, D.S. Houser, & J.J. Finneran. (2007). Simultaneously measured behavioral and electrophysiological hearing thresholds in a bottlenose dolphin (*Tursiops truncatus*). *Journal of the Acoustical Society of America* 122:615-622.

Schoenherr, J.R. (1991). Blue whales feeding on high concentrations of euphausiids around Monterey Submarine Canyon. *Canadian Journal of Zoology* 69:583-594.

Schotten, M., W.W.L. Au, M.O. Lammers, & R. Aubauer. (2004). Echolocation recordings and localization of wild spinner dolphins (*Stenella longirostris*) and pantropical spotted dolphins (S. *attenuata*) using a four-hydrophone array. Pages 393-400 in J.A. Thomas, C.F. Moss and M. Vater, eds. *Echolocation in bats and dolphins*. Chicago, Illinois: University of Chicago Press.

Schreer, J.F., K.M. Kovacs, & R.J.O. Hines. (2001). Comparative diving patterns of pinnipeds and seabirds. *Ecological Monographs* 71:137-162.

Schusterman, R. J., D. Kastak, D.H. Levenson, C.J. Reichmuth, & B.L. Southall. (2000). Why pinnipeds don't echolocate. *Journal of the Acoustical Society of America* 107:2256-2264.

Schwartz, M., A. Hohn, A. Bernard, S. Chivers, & K. Peltier. (1992). *Stomach contents of beach cast cetaceans collected along the San Diego County coast of California, 1972-1991*. Southwest Fisheries Science Center Administrative Report LJ-92-18. La Jolla, California: National Marine Fisheries Service.

Scott, M.D. & K.L. Cattanach. (1998). Diel patterns in aggregations of pelagic dolphins and tuna in the eastern Pacific. Marine Mammal Science. 14:401-428. Scott M.D., A.A. Hohn., A.J. Westgate, J.R. Nicolas., B.R. Whitaker and W.B Campbell. 2001. A note on the release and tracking of a rehabilitated pygmy sperm whale (*Kogia breviceps*). *Journal of Cetacean Research and Management* 3:87-94.

Scott, T. M. & S. S. Sadove. (1997). Sperm whale, *Physeter macrocephalus*, sightings in the shallow shelf waters off Long Island, New York. *Marine Mammal Science* 13:317-321.

Scowcroft, G., K. Vigness Raposa, C. Knowlton, & J. Johnen. (2006). Discovery of Sound in the Sea. University of Rhode Island.

Sears, R., J.M. Williamson, F.W. Wenzel, M. Bérubé, D. Gendron, & P. Jones. (1990). Photographic identification of the blue whale (*Balaenoptera musculus*) in the Gulf of St. Lawrence, Canada. *Reports of the International Whaling Commission, Special Issue* 12:335-342.

Selzer, L.A. & P.M. Payne. (1988). The distribution of white-sided dolphins. *Lagenorhynchus acutus*) and common dolphins. *Delphinus delphis*) vs. environmental features of the continental shelf of the northeastern United States. *Marine Mammal Science* 4:141-153.

Sergeant, D.E. (1982). Some biological correlates of environmental conditions around Newfoundland during 1970-1979: harp seals, blue whales and fulmar petrels. North Atlantic Fisheries Organization. NAFO. *Scientific Council Studies* 5:107-110.

Seyle, H. (1950). Stress and the general adaptation syndrome. *British Medical Journal* 1383-1392.

Shallenberger, E.W. (1981). *The status of Hawaiian cetaceans*. (Report prepared under Contract #MM7AC028 for the Marine Mammal Commission, Washington, D.C.)

Shane, S.H. (1994). Occurrence and habitat use of marine mammals at Santa Catalina Island, California from 1983-91. *Bulletin of the Southern California Academy of Sciences* 93:13-29.

Shane, S.H. & D. McSweeney. (1990). Using photo-identification to study pilot whale social organization. *Reports of the International Whaling Commission, Special Issue* 12. 259-263.

Shelden, K.E.W., S.E. Moore, J.M. Waite, P.R. Wade, & D.J. Rugh. (2005). Historic and current habitat use by North Pacific right whales *Eubalaena japonica* in the Bering Sea and Gulf of Alaska. *Mammal Review* 35:129-1 55.

Shipley, C., B.S. Stewart, & J. Bass. (1992). Seismic communication in northern elephant seals. Pages 553-562 in J.A. Thomas, R.A. Kastelein, & A.Y. Supin, eds. *Marine mammal sensory systems.* New York: Plenum Press.

Silber, G.K. (1986). The relationship of social vocalizations to surface behavior and aggression in the Hawaiian humpback whale (*Megaptera novaeangliae*). *Canadian Journal of Zoology* 64:2075-2080.

Simão, S.M. & S.C. Moreira. (2005). Vocalizations of a female humpback whale in Arraial do Cabo (RJ, Brazil). *Marine Mammal Science* 21:150-153.

Simpson, J.H., P.B. Tett, M.L. Argote-Espinoza, A. Edwards, K.J. Jones, & G. Savidge. (1982). Mixing and phytoplankton growth around an island in a stratified sea. *Continental Shelf Research* 1:15-31.

Simmonds, M.P. & L.F. Lopez-Jurado. (1991). Whales and the military. *Nature* 351:448.

Simmonds, M.P & J.D. Hutchinson. (1996). *The Conservation of Whales and Dolphins: Science and Practice.* John Wiley & Sons, Chichester, UK.

Simmonds, M.P. & S.J. Mayer. (1997). An evaluation of environmental and other factors in some recent marine mammal mortalities in Europe: implication for conservation and management. *Environmental Review* 5:89-98.

Širović, A., J.A. Hildebrand, & Sean M. Wiggins. (2007). Blue and fin whale call source levels and propagation range in the Southern Ocean. *Journal of the Acoustical Society of America* 122:1208-1215.

Slijper, E.J., W.L. van Utrecht, & C. Naaktgeboren. (1964). Remarks on the distribution and migration of whales, based on observations from Netherlands ships. *Bijdragen Tot de Dierkunde* 34:3-93.

Smith, M.E., A.S. Kane, & A.N. Popper. (2004). Acoustical stress and hearing sensitivity in fishes: does the linear threshold shift hypothesis hold water? *Journal of Experimental Biology* 207:3591-3602.

Smultea, M.A., J.R. Mobley, Jr., D. Fertl, & G.L. Fulling. (2008). An unusual reaction and other observations of sperm whales near fixed-wing aircraft. *Gulf and Caribbean Research* 20:75-80.

Soto, N.A., M. Johnson, P.T. Madsen, P.L. Tyack, A. Bocconcelli & J.F. Borsani. (2006). Does intense ship noise disrupt foraging in deep-diving Cuvier's beaked whales (*Ziphius cavirostris*)? *Marine Mammal Science* 22:690-699.

Southall, B.L., R.J. Schusterman, D. Kastak, & C. Reichmuth-Kastak. (2005). Reliability of underwater hearing thresholds in pinnipeds. *ARLO* 6:243–249.

Southall, B.L. (2006). *Declaration of Brandon L. Southall, Ph.D. Natural Resources Defense Council v Donald C. Winter (RIMPAC), June 30, 2006*.

Southall, B.L., R. Braun, F.M. D. Gulland, A.D. Heard, R. Baird, S. Wilkin & T.K. Rowles. (2006). *Hawaiian melon-headed whale (Peponocephala electra) mass stranding event of July 3-4, 2004.* (NOAA Technical Memorandum NMFS-OPR-31. 73 pp).

Southall, B.L., A.E. Bowles, W.T. Ellison, J.J. Finneran, R.L. Gentry, C.R. Greene, D. Kastak, D.R. Ketten, J.H. Miller, P.E. Nachtigall, W.J Richardson, J.A. Thomas, & P.L. Tyack. (2007). Marine Mammal Noise Exposure Criteria: Initial Scientific Recommendations. *Aquatic Mammals* 33:411-521.

Stacey, P.J. & R.W. Baird. (1991). Status of the false killer whale, *Pseudorca crassidens*, in Canada. *Canadian Field-Naturalist* 105:189-197.

Stafford, K.M. (2003). Two types of blue whale calls recorded in the Gulf of Alaska. *Marine Mammal Science* 19:682-693.

Stafford, K.M., C.G. Fox, & D.S. Clark. (1998). Long-range acoustic detection and localization of blue whale calls in the northeast Pacific Ocean. *Journal of Acoustical Society of America* 104:3616-3625.

Stafford, K.M., S.L. Nieukirk, & C.G. Fox. (1999). Low-frequency whale sounds recorded on hydrophones moored in the eastern tropical Pacific. *Journal of Acoustical Society of America* 106:3687-3698.

Stafford, K.M., S.L. Nieukirk, & C.G. Fox. (2001). Geographic and seasonal variation of blue whale calls in the North Pacific. *Journal of Cetacean Research and Management* 3:65-76.

Stafford, K.M., S.E. Moore, & C.G. Fox. (2005). Diel variation in blue whale calls recorded in the eastern tropical Pacific. *Animal Behaviour* 69:951-958.

Stern, J.S. (1992). Surfacing rates and surfacing patterns of minke whales (*Balaenoptera acutorostrata*) off central California, and the probability of a whale surfacing within visual range. *Reports of the International Whaling Commission* 42:379-385.

Stevick, P.T., B.J. McConnell, & P.S. Hammond. (2002). Patterns of movement. Pages 185-216 in A.R. Hoelzel, ed. *Marine mammal biology: An evolutionary approach*. Oxford: Blackwell Science.

Stewart, B.S., P.K. Yochem, H.R. Huber, R.L. DeLong, R.J. Jameson, W.J. Sydeman, S.G. Allen, & B.J. Le Boeuf. (1994). History and present status of the northern elephant seal population. Pages 29-48 in B.J. Le Boeuf and R.M. Laws, eds. *Elephant seals: Population ecology, behavior, and physiology*. Berkeley: University of California Press.

Stewart, B. S. & S. Leatherwood. (1985). Minke whale Balaenoptera acutorostrata Lacepede, 1804. Pages 91-136 in Ridgway, S.H. and R. Harrison, eds. *Handbook of marine mammals. Volume 3: The sirenians and baleen whales*. Academic Press: San Diego, California.

Stewart, B.S. & R.L. DeLong. (1995). Double migrations of the northern elephant seal, *Mirounga angustirostris*. *Journal of Mammalogy* 76:196-205

Stewart, B.S. (1997). Ontogeny of differential migration and sexual segregation in northern elephant seals. *Journal of Mammalogy* 78:1101-1116.

Stone, C.J. & M.J. Tasker. (2006). The effects of seismic airguns on cetaceans in U.K. waters. *Journal of Cetacean Research and Management* 8:255-263.

Stone, G.S., S.K. Katona, A. Mainwaring, J.M. Allen, & H.D. Corbett. (1992). Respiration and surfacing rates for finback whales (*Balaenoptera physalus*) observed from a lighthouse tower. *Reports of the International Whaling Commission* 42:739-745.

Sullivan, M.J. & R.B. Conolly. (1988). Dose-response hearing loss for white noise in the Sprague-Dawley rat. *Toxicological Sciences* 10:109-113

Summary Papers on Human and Animal Hearing Effects in Air. (1991). *Special section in Journal of the Acoustical Society of America* 90:124-227.

Suter, G.W., L.W. Barnthouse, S.M. Bartell, T. Mill, D. Mackay, & S. Paterson. (1993). *Ecological risk assessment*. Lewis Publishers, Boca Raton, Florida.

Swartz, S.L. (1986). Gray whale migratory, social and breeding behavior. (*Eschrichtius robustus*). *Reports of the International Whaling Commission, Special Issue* 8:207-229.

Swartz, S.L., A. Martinez, J. Stamates, C. Burks, & A.A. Mignucci-Giannoni. (2002). *Acoustic and visual survey of cetaceans in the waters of Puerto Rico and the Virgin Islands: February-March 2001*. (NOAA Technical Memorandum NMFS-SEFSC-463:l-62).

Sweeny, M. M., J. M. Price, G. S. Jones, T. W. French, G. A. Early, & M. J. Moore. (2005). Spondylitic changes in long-finned pilot whales (*Globicephala melas*) stranded on Cape Cod, Massachusetts, USA, between 1982 and 2000. *Journal of Wildlife Diseases* 41:717-727.

Swingle, W.M., S.G. Barco, T.D. Pitchford, W.A. McLellan, & D.A. Pabst. (1993). Appearance of juvenile humpback whales feeding in the nearshore waters of Virginia. *Marine Mammal Science* 9:309-315.

Swets, J.A. (1964). *Signal Detection and Recognition by Human Observers, Contemporary Reading.* John Wiley and Sons, New York.

Szymanski, M.D., D.E. Bain, K. Kiehl, S. Pennington, S. Wong, & K.R. Henry. (1999). Killer whale (*Orcinus orca*) hearing: auditory brainstem response and behavioral audiograms. *Journal of the Acoustical Society of America* 106:1134-1141.

Thode, A., D.K. Mellinger, S. Stienessen, A. Martinez, & K. Mullin. (2002). Depth-dependent acoustic features of diving sperm whales (*Physeter macrocephalus*) in the Gulf of Mexico. *Journal of the Acoustical Society of America* 112:308-321.

Thomas, J., N. Chun, W. Au, & K. Pugh. (1988). Underwater audiogram of a false killer whale (*Pseudorca crassidens*). *Journal of the Acoustical Society of America* 84:936-940.

Thomas, J. & R. Kastelein. (1990). *Sensory Abilities of Cetaceans*. Plenum Press, New York.

Thomas, J., P. Moore, R. Withrow, & M. Stoermer. (1990). Underwater audiogram of a Hawaiian monk seal (*Monachus schauinslandi*). *Journal of the Acoustical Society of America* 87:417-420.

Thompson, P.O. & W.A. Friedl. (1982). A long term study of low frequency sounds from several species of whales off Oahu, Hawaii. *Cetology* 45:l-19.

Thompson, P.O., W.C. Cummings, & S.J. Ha. (1986). Sounds, source levels, and associated behavior of humpback whales, southeast Alaska. *Journal of the Acoustical Society of America* 80:735-740.

Thompson, T.J., H.E. Winn, & P.J. Perkins. (1979). Mysticete sounds. In *Behavior of marine animals, Volume 3.* H.E. Winn and B.L. Olla, (eds.), Plenum, NY. 438 pp.

Thorson, P.H., G.L. Fulling, J.A. Rivers, S. Watterson, & K. Sawyer. (2007). *Cetacean diversity, distribution and abundance in Marianas waters from a boreal winter survey in 2007*. Seventeenth Biennial Conference on the Biology of Marine Mammals. Cape Town, South Africa. 29 November to 3 December 2007.

Thurman, H.V. (1997). *Introductory oceanography*. Upper Saddle River, New Jersey: Prentice Hall.

Tomich, P.Q. (1986). Mammals in Hawaii: A synopsis and notational bibliography. *Honolulu: Bishop Museum Press.*

Townsend, C.H. (1935). The distribution of certain whales as shown by logbook records of American whaleships. *Zoologica* 19:1-50.

Tracey, R. (2000). *Mass false killer whale beaching remains a mystery*. Discovery Channel Canada's Website. Retrieved February 12, 2007 from http://www.exn.ca/Stories/2000/06/05/56.asp

Trimper, P.G., N.M. Standen, L.M. Lye, D. Lemon, T.E. Chubbs, & G.W. Humphries. (1998). Effects of low-level jet aircraft noise on the behaviour of nesting osprey. *The Journal of Applied Ecology* 35:9.

Turl, C.W. (1993). Low-frequency sound detection by a bottlenose dolphin. Journal of the *Acoustical Society of America* 94:3006-3008.

Tyack, P.L. & H. Whitehead. (1983). Male competition in large groups of wintering humpback whales. *Behaviour* 83:132-153.

Tyack, P.L., M.P. Johnson, N. Aguilar Soto, A. Sturlese, & P.T. Madsen. (2006a). Extreme diving of beaked whales. Journal of Experimental Biology. 209:4238-4253.

Tyack, P.L., M.P. Johnson, W.M.X. Zimmer, P.T. Madsen, & M.A. de Soto. (2006b). Acoustic behavior of beaked whales, with implications for acoustic monitoring. Oceans 2006.1-6.

Tynan, C.T., D.P. DeMaster, & W.T. Peterson. (2001). Endangered right whales on the southeastern Bering Sea shelf. *Science* 294:1894.

Urian, K.W., D.A. Duffield, A.J. Read, R.S. Wells, & E.D. Shell. (1996). Seasonality of reproduction in bottlenose dolphins, *Tursiops truncatus*. *Journal of Mammalogy* 77:394-403.

Urick, R.J. (1983). *Principles of Underwater Sound for Engineers.* McGraw-Hill, NY.

U.S. Air Force. (2002). *Eglin Gulf Test and Training Range Programmatic Environmental Assessment.* Air Armament Center, 46 TW/XPE Range Environmental Planning Office, Eglin Air Force Base, Florida.

U.S. Department of Commerce & Department of the Navy. (2001). *Joint Interim Report, Bahamas Marine Mammal Stranding Event of 15-16 March 2000.*

U.S. Department of the Navy. Naval Sea Systems Command, *NAVSEA Instruction 3150.2: Safe Diving Distances from Transmitting Sonar.*

U.S. Department of the Navy. (1995). *Environmental Assessment of the Use of Underwater Acoustic and Explosive Sources during Exercise Standard EIGER.* SSBN Security Program Office.

U.S. Department of the Navy. (1996). *Environmental Assessment of the Use of Selected Navy Test Sites for Development Tests and Fleet Training Exercises of the MK 48 Torpedoes*. Program Executive Office Undersea Warfare: Program Manager for Undersea Weapons.

U.S. Department of the Navy. (1997). *Environmental Impact Statement for Shock Testing the Seawolf Submarine.*

U.S. Department of the Navy. (1999). *Request for letter of authorization for the incidental take of marine mammals associated with the employment of surveillance towed array sensor system low frequency active (SURTASS LFA) sonar*. Chief of Naval Operations: Washington, DC. 79 pp.

U.S. Department of the Navy. (2001a). *Environmental Impact Statement for the Shock Trial of the Winston S. Churchill, (DDG-81).*

U.S. Department of the Navy. (2001b). *Final Overseas Environmental Impact Statement and Environmental Impact Statement for Surveillance Towed Array Sensor System Low Frequency Active (SURTASS LFA) Sonar*. Chief of Naval Operations.

U.S. Department of the Navy. (2004a). See Fromm, D. (2004a) *Acoustic Modeling Results of the Haro Strait For 5 May 2003.* (Naval Research Laboratory Report, Office of Naval Research, 30 January 2004).

U.S. Department of the Navy. (2004b). See Fromm, D. (2004b) EEEL Analysis of U.S.S. SHOUP Transmissions in the Haro Strait on 5 May 2003. *Naval Research Laboratory briefing of 2 September 2004*.

U.S. Department of the Navy. (2004c). See Department of the Navy, Commander U.S. Pacific Fleet 2003. (Report on the Results of the Inquiry into Allegations of Marine Mammal Impacts Surrounding the Use of Active Sonar by *U.S.S. SHOUP* (DDG 86) in the Haro Strait on or about 5 May 2003).

U.S. Department of the Navy. (2005a). *Marine Resources Assessment for the Marianas Operating Area.* Commander. U.S. Pacific Fleet. 416 pp.

U.S. Department of the Navy. (2005b). *Draft Overseas Environmental Impact Statement/Environmental Impact Statement (OEIS/EIS), Undersea Warfare Training Range*. Commander, U.S. Atlantic Fleet.

U.S. Department of the Navy. (2006a). *2006 Supplement to the 2002 RIMPAC Programmatic Environmental Assessment*. Commander, Third Fleet.

U.S. Department of the Navy. (2006b). *Undersea Warfare Exercise (USWEX) EA/OEA*. Commander, Third Fleet.

U.S. Department of the Navy. (2007a). *Final Supplemental Environmental Impact Statement for Surveillance Towed Array Sensor System Low Frequency Active (SURTASS LFA) Sonar.* Chief of Naval Operations.

U.S. Department of the Navy. (2007b). *Marine mammal and sea turtle survey and density estimates for Guam and the Commonwealth of the Northern Mariana Islands*. Pacific Fleet, Naval Facilities Engineering Command, Pacific: Honolulu, Hawaii.

U.S. Department of the Navy. (2007c). *Undersea Warfare Exercise Programmatic Environmental Assessment*. Pacific Fleet, Naval Facilities Engineering Command, Pacific: Honolulu, Hawaii.

U.S. Department of the Navy. (2007d). *Joint Task Force Exercises and Composite Unit Training Exercises, Environmental Assessment/Overseas Environmental Assessment*. U.S. Pacific Third Fleet.

U.S. Department of the Navy. (2008). *Final Environmental Impact Statement/Overseas Environmental Impact Statement, Hawaii Range Complex.* Chief of Naval Operations.

U.S. Department of Navy & Department of Commerce. (2001). *Joint Interim Report Bahamas Marine Mammal Stranding Event of 15-16 March 2000.* D.L. Evans, U.S. Dept. of Commerce, Secretary; G.R. England, Secretary of the Navy.

Vanderlaan, A.S.M., A.E. Hay, & C.T. Taggart. (2003). Characterization of North Atlantic right-whale (*Eubalaena glacialis*) sounds in the Bay of Fundy. *IEEE Journal of Oceanic Engineering* 28:164-173.

Van Dolah, F.M., G.J. Doucette, F.M.D. Gulland, T.L. Rowles, & G.D. Bossart. (2003). Impacts of algal toxins on marine mammals. IN: J.G. Vos, G.D. Bossart, M. Fournier, & T.J. O'Shea, eds. *Toxicology of Marine Mammals*. Taylor & Francis, London and New York. pp. 247-269.

Van Dolah, F.M. (2005). Effects of Harmful Algal Blooms. IN: J.E. Reynolds III, W.F. Perrin, R.R. Reeves, S. Montgomery, T.J. Ragen. *Marine Mammal Research*. John Hopkins University Press, Baltimore. pp. 85-99.

Veirs, V. (2004). Source levels of free-ranging killer whale (*Orcinus orca*) social vocalizations. *Journal of the Acoustical Society of America* 116:2615.

Visser, I.K.G., J.S. Teppema, & A.D.M.E. Ostrhaus. (1991). Virus infections of seals and other pinnipeds. *Reviews in Medical Microbiology* 2:105-114.

Visser, I.N. & F.J. Bonoccorso. (2003). New observations and a review of killer whale (*Orcinus orca*) sightings in Papua New Guinea waters. *Aquatic Mammals* 29:150-172. 6

Von Saunder, A. & J. Barlow. (1999). *A report of the Oregon, California and Washington line-transect experiment (ORCAWALE) conducted in West Coast waters during Summer/Fall 1996.* (NOAA Technical Memorandum NMFS-SWFSC-264:1-49).

Wade, L.S. & G.L. Friedrichsen. (1979). Recent sightings of the blue whale, *Balaenoptera musculus*, in the northeastern tropical Pacific. *Fishery Bulletin* 76:915-919.

Wade, P.R & T. Gerrodette. (1993). Estimates of cetacean abundance and distribution in the eastern tropical Pacific. *Reports of the International Whaling Commission* 43:477-493.

Wade, P., M.P. Heide-Jørgensen, K. Shelden, J. Barlow, J. Carretta, J. Durban, R. LeDuc, L. Munger, S. Rankin, A. Sauter, & C. Stinchcomb. (2006). Acoustic detection and satellite-tracking leads to discovery of rare concentration of endangered North Pacific right whales. *Biological Letters* 3pp.

Wahlberg, M. (2002). The acoustic behaviour of diving sperm whales observed with a hydrophone array. *Journal of Experimental Marine Biology and Ecology* 281:53-62.

Walker, M.M., J.L. Kirschvink, G. Ahmed, & A.E. Dicton. (1992). Evidence that fin whales respond to the geomagnetic field during migration. *Journal of Experimental Biology* 171:67-78.

Walsh, M.T., Ewing, R.Y., Odell, D. K., & Bossart, G.D. (2001). *Mass Strandings of Cetaceans. in Marine Mammal Medicine*. Eds.by L. A. Dierauf, & F. M. D. Gulland (CRC Press, Boca Raton), pp. 83-96.

Walker, W.A. (1981). *Geographical variation in morphology and biology of bottlenose dolphins (Tursiops) in the eastern North Pacific*. Southwest Fisheries Science Center Administrative Report LJ-81-03C. La Jolla, California: National Marine Fisheries Service.

Walker, R.J., E.O. Keith, A.E. Yankovsky & D.K. Odell. (2005). Environmental correlates of cetacean mass stranding in sites in Florida. *Marine Mammal Science* 21:327-335.

Walker, W.A., J.G. Mead, & R.L. Brownell. (2002). Diets of Baird's beaked whales *Berardius bairdii*, in the southern Sea of Okhotsk and off the Pacific Coast of Honshu, Japan. *Marine Mammal Science* 18:902-919.

Walsh, W.A. & D.R. Kobayashi. (2004). *A description of the relationships between marine mammals and the Hawaii-based longline fishery from 1994 to 2003.* (Report prepared by the University of Hawaii and Pacific Islands Fisheries Science Center).

Wang, M.-.C., W.A. Walker, K.T. Shao, & L.S. Chou. (2002). Comparative analysis of the diets of pygmy sperm whales and dwarf sperm whales in Taiwanese waters. *Acta Zoologica Taiwanica* 13:53-62.

Ward, W.D. (1960). Recovery from high values of temporary threshold shift. *Journal of the Acoustical Society of America* 32:497–500.

Ward, W.D. (1997). Effects of high-intensity sound. In *Encyclopedia of Acoustics*, ed. M.J. Crocker, 1497-1507. New York: Wiley.

Ward, W.D., A. Glorig, & DL. Sklar. (1958). Dependence of temporary threshold shift at 4 kc on intensity and time. *Journal of the Acoustical Society of America* 30:944–954.

Ward, W.D., A. Glorig, & D.L. Sklar. (1959). Temporary threshold shift from octave-band noise: Applications to damage-risk criteria. *Journal of the Acoustical Society of America* 31:522–528.

Waring, G.T. & J. T. Finn. (1995). *Cetacean trophic interactions off the northeast USA inferred from spatial and temporal co-distribution patterns*. ICES C.M, 1995/N:7:1-44. International Council for the Exploration of the Sea: Copenhagen, Denmark. Unpublished meeting document.

Waring, G.T., T. Hamazaki, D. Sheehan, G. Wood, & S. Baker. (2001). Characterization of beaked whale (Ziphiidae) and sperm whale (*Physeter macrocephalus*) summer habitat in shelf-edge and deeper waters off the northeast U. S. *Marine Mammal Science* 17:703-717.

Waring, G.T., J.M. Quintal, & C.P. Fairfield, eds. (2002). *U.S. Atlantic and Gulf of Mexico marine mammal stock assessments – 2002.* (NOAA Technical Memorandum NMFS-NE-169:1-318).

Wartzok, D. & D.R. Ketten. (1999). Marine Mammal Sensory Systems. *Biology of Marine Mammals*, ed. J.E. Reynolds III and S.A. Rommel. pp 324-422.

Wartzok, D., A.N. Popper, J. Gordon, & J. Merrill. (2003). Factors affecting the responses of marine mammals to acoustic disturbance. *Marine Technology Society Journal* 37:6-15.

Watkins, W.A. & W.E. Schevill. (1977). Sperm whale codas. *Journal of the Acoustical Society of America* 62:1485-1490.

Watkins, W.A., K.E. Moore, & P. Tyack. (1985). Sperm whale acoustic behaviors in the southeast Caribbean. *Cetology* 49:1-15.

Watkins, W.A., P. Tyack, K.E. Moore, & J.E. Bird. (1987). The 20-Hz signals of finback whales (*Balaenoptera physalus*). *Journal of the Acoustical Society of America* 82:1901-1912.

Watkins, W.A., M.A. Daher, A. Samuels, & D.P. Gannon. (1997). Observations of *Peponocephala electra*, the melon-headed whale, in the southeastern Caribbean. *Caribbean Journal of Science* 33:34-40.

Watkins, W.A., M.A. Daher, K.M. Fristrup, & T.J. Howald. (1993). Sperm whales tagged with transponders and tracked underwater by sonar. *Marine Mammal Science* 9:55-67.

Watkins, W.A., M.A. Daher, N.A. DiMarzio, A. Samuels, D. Wartzok, K.M. Fristrup, P.W. Howey, & R.R. Maiefski. (2002). Sperm whale dives tracked by radio tag telemetry. *Marine Mammal Science* 18:55-68.

Watwood, S.L., P.J.O. Miller, M. Johnson, P.T. Madsen & P.L. Tyack. (2006). Deep-diving foraging behaviour of sperm whales (*Physeter macrocephalus*). *Journal of Ecology* 75:814-825.

Weilgart, L. & H. Whitehead. (1997). Group-specific dialects and geographical variation in coda repertoire in South Pacific sperm whales. *Behavioral Ecology and Sociobiology* 40:277-285.

Weise, M.J., D.P. Costa, & R.M. Kudela. (2006). Movement and diving behavior of male California sea lion (*Zalophus californianus*) during anomalous oceanographic conditions of 2005. *Geophysical Research Letters* 33:L22S10.

Welch, B.L. & A.S. Welch (eds.). (1970). *Physiological effects of noise*. Plenum Press, New York, NY.

Weller, D.W., B. Würsig, H. Whitehead, J.C. Norris, S.K. Lynn, R.W. Davis, N. Clauss, & P. Brown. (1996). Observations of an interaction between sperm whales and short-finned pilot whales in the Gulf of Mexico. *Marine Mammal Science* 12:588-594.

Wells, R.S., D.J. Boness, & G.B. Rathbun. (1999). Behavior. *Biology of Marine Mammals*, ed. J.E. Reynolds III and S.A. Rommel. Pp 117-175.

Westlake, R.L. & W.G. Gilmartin. (1990). Hawaiian monk seal pupping locations in the Northwestern Hawaiian Islands. *Pacific Science* 44:366-383.

Weston, D.E. (1960). *Underwater Explosions as Acoustic Sources*. Proceedings of the Physics Society. 76: 233.

Whitehead, H. (2003). *Sperm whales: Social evolution in the ocean*. Chicago: University of Chicago Press.

Whitehead, H. & L. Weilgart. (1991). Patterns of visually observable behaviour and vocalizations in groups of female sperm whales. *Behaviour* 118:276-296.

Whitehead, H, S. Brennan & D. Grover. (1992). Distribution and behaviour of male sperm whales on the Scotian Shelf, Canada. *Canadian Journal of Zoology* 70:912-918.

Wiggins, S.M., M.A. McDonald, L.M. Munger, S.E. Moore, & J.A. Hildebrand. (2004). Waveguide propagation allows range estimates for North Pacific right whales in the Bering Sea. *Canadian Acoustics* 32:146-154.

Wilkinson, D.M. (1991). *Report to the Assistant Administrator for Fisheries, in Program Review of the Marine Mammal Stranding Network*. U.S. Department of Commerce, National Oceanographic and Atmospheric Administrations, National Marine Fisheries Service, Silver Springs, MD. 171 pp.

Willis, P.M. & R.W. Baird. (1998). Status of the dwarf sperm whale, *Kogia simus*, with special reference to Canada. *Canadian Field-Naturalist* 112:114-125.

Winn, H.E. & P.J. Perkins. (1976). Distribution and sounds of the minke whale, with a review of mysticete sounds. *Cetology* 19:1-12.

Winn, H.E., J.D. Goodyear, R.D. Kenney, & R.O. Petricig. (1995). Dive patterns of tagged right whales in the Great South Channel. *Continental Shelf Research* 15:593-611.

Witteveen, B.H., J.M. Straley, O. Von Ziegesar, D. Steel, & C.S. Baker. (2004). Abundance and mtDNA differentiation of humpback whales (*Megaptera novaeangliae*) in the Shumagin Islands, Alaska. *Canadian Journal of Zoology* 82:1352-1359.

Wolanski, E., R.H. Richmond, G. Davis, E. Deleersnijder, & R.R. Leben. (2003). Eddies around Guam, an island in the Mariana Islands group. *Continental Shelf Research* 23:991-1003.

Woods Hole Oceanographic Institution. (2005). *Beaked Whale Necropsy Findings for Strandings in the Bahamas, Puerto Rico, and Madiera,1999–2002*. (Technical Report, WHOI-2005-09).

Woodward, B.L. & J.P. Winn. (2006). Apparent lateralized behavior in gray whales feeding off the central British Columbia coast. *Marine Mammal Science* 22:64-73.

Würsig, B., S.K. Lynn, T.A. Jefferson, & K.D. Mullin. (1998). Behaviour of cetaceans in the northern Gulf of Mexico relative to survey ships and aircraft. *Aquatic Mammals* 24:41-50.

Würsig, B. & W.J. Richardson. (2002). Effects of Noise, Pages 794-802 in W. F. Perrin, B. Wursig, & J. G. M. Thewissen, eds. *Encyclopedia of Marine Mammals*. San Diego.

Yelverton, J.T. (1981). *Underwater Explosion Damage Risk Criteria for Fish, Birds, and Mammals.* Manuscript, presented at 102nd Meeting of the Acoustical Society of America, Miami Beach, FL, December, 1982. 32pp.

Yochem, P.K. & S. Leatherwood. (1985). Blue whale-*Balaenoptera musculus*. Pages 193-240 in S.H. Ridgway and R. Harrison, eds. *Handbook of Marine Mammals. Volume 3: The sirenians and baleen whales.* San Diego: Academic Press.

Yost, W.A. (1994). *Fundamentals of Hearing: An Introduction*. San Diego: Academic Press.

Yu, H-Y., H-K. Mok, R-C. Wei, & L-S., Chou. (2003). Vocalizations of a rehabilitated rough-toothed dolphin, *Steno bredanensis*. Page 183 in *Abstracts, Fifteenth Biennial Conference on the Biology of Marine Mammals*. 14–19 December 2003. Greensboro, North Carolina.

Yuen, M.E., P.E Nachtigall, & A.Ya Supin. (2005). Behavioral and AEP Audiograms of a false killer whale (*Pseudorca crassidens*). *Journal of the Acoustical Society of America*. 118: 2688-2695.

Zeeberg, J., A. Corten, & E. de Graaf. (2006). Bycatch and release of pelagic megafauna in industrial trawler fisheries off Northwest Africa. *Fisheries Research* 78:186-195.

Zeeberg, J., A. Corten & E. de Graaf. (2006). Bycatch and release of pelagic megafauna in industrial trawler fisheries off Northwest Africa. *Fisheries Research* 78: 186-195.

Zimmer, W.M.Z., P.L. Tyack, M.P. Johnson, & P.T. Madsen. (2005). Three-dimensional beam pattern of regular sperm whale clicks confirms bent-horn hypothesis. *Journal of the Acoustical Society of America* 117:1473-1485.

Zimmer, W.M. X. & P.L. Tyack. (2007). Repetitive shallow dives pose decompression risk in deep-diving beaked whales. *Marine Mammal Science* 23:888-925.

Zimmerman, S.T. (1991). *A History of Marine Mammal Stranding Networks in Alaska, with Notes on the Distribution of the Most Commonly Stranded Cetacean Species, 1975-1987*. Marine Mammal Strandings in the United States, Miami, FL, NMFS.

Zoidis, A.M., M.A. Smultea, A.S. Frankel, J.L. Hopkins, A. Day, A.S. McFarland, A.D. Whitt, & D. Fertl. (2008). Vocalizations produced by humpback whale *(Megaptera novaeangliae)* calves recorded in Hawaii. *Journal of Acoustical Society of America* 123(3):1737-1746.

Section 3.8 References: Sea Turtles

Balazs, G.H. (1980). *Synopsis of biological data on the green turtle in the Hawaiian Islands*. (NOAA Technical Memorandum NMFS-SWFC-7:1-141).

Bartol, S.M. & J.A. Musick. (2003). Sensory biology of sea turtles. Pages 79-102 in Lutz, P.L., J.A. Musick, and J. Wyneken, eds. *The biology of sea turtles, Volume 2*. Boca Raton, Florida: CRC Press.

Bartol, S.M., J.A. Musick, and M.L. Lenhardt. (1999). Auditory evoked potentials of the loggerhead sea turtle (*Caretta caretta*), *Copeia,* 3:836-840.

Bass, A.L. (1994). Population structure of hawksbill rookeries in the Caribbean and western Atlantic. Page 17 in K.A. Bjorndal, A.B. Bolten, D.A. Johnson, and P.J. Eliazar, eds. *Proceedings of the Fourteenth Annual Symposium on Sea Turtle Biology and Conservation: 1 - 5 March 1994, Hilton Head, South Carolina.* (NOAA Technical Memorandum NMFS-SEFSC-351).

Beale, C. M. & P. Monaghan. (2004). Human disturbance: people as predation-free predators? *Journal of Applied Ecology* 41:335-343.

Belt Collins Hawaii. (2001). Year 2001 Assessment of Marine and Fisheries Resources Farallon de Medinilla, Commmonwealth of the Northern Mariana Islands Final Report. Prepared for the Department of the Navy.

Bjorndal, K.A. (1985). *Nutritional ecology of sea turtles*. Copeia 1985(3):736-751.

Bjorndal, K.A. (1997). Foraging ecology and nutrition of sea turtles. Pages 199-231 in Lutz, P.L. and J.A. Musick, eds. *The biology of sea turtles*. Boca Raton, Florida: CRC Press.

Brill, R.W., G.H. Balazs, K.N. Holland, R.K.C. Chang, S. Sullivan, & J. George. (1995). Daily movements, habitat use, and submergence intervals of normal and tumor-bearing juvenile green turtles (*Chelonia mydas* L.) within a foraging area in the Hawaiian Islands. *Journal of Experimental Marine Biology and Ecology* 185:203-218.

Burke, V.J., S.J. Morreale, P. Logan, & E.A. Standora. (1992). Diet of green turtles (*Chelonia mydas*) in the waters of Long Island, N.Y. Pages 140-142 in Salmon, M. and J. Wyneken, eds. *Proceedings* *of the Eleventh Annual Workshop on Sea Turtle Biology and Conservation*. (NOAA Technical Memorandum NMFS-SEFSC-302).

Carr, A. (1987a). New perspectives on the pelagic stage of sea turtle development. *Conservation Biology* 1(2):103-121.

Carr, A. (1987b). Impact of nondegradable marine debris on the ecology and survival outlook of sea turtles. *Marine Pollution Bulletin* 18(6B):352-356.

Chaloupka, M.Y., & G.H. Balazs. (2005). Modeling the effect of fibropapilloma disease on the somatic growth dynamics of Hawaiian green sea turtles. *Marine Biology,* 147:1251–1260.

Chaloupka, M.Y., & J.A. Musick (1997) Age, growth, and population dynamics. pp. 233-276. In: P.L. Lutz and J.A. Musick, eds. *The biology of sea turtles,* Boca Raton, Florida: CRC Press.

Chaloupka, M.Y., T. Work, G.H. Balazs, S.K.K. Murakawa & R. Morris. (2008). Cause-specific temporal and spatial trends in green turtle strandings in the Hawaiian Archipelago (1982-2003). *Marine Biology* 154:887-898.

Collard, S.B. (1990). Leatherback turtles feeding near a warmwater mass boundary in the eastern Gulf of Mexico. Marine Turtle Newsletter 50:12-14.

Davenport, J., (1997). "Temperature and the life-history strategies of sea turtles," *Journal of Thermal Biology,* 22:479-488.

Dodd, C.K. (1988). Synopsis of the biological data on the loggerhead sea turtle *Caretta caretta* (Linnaeus 1758). U.S. Fish and Wildlife Service Biological Report 88(14):1-110.

Dutton, P.H., S.K. Davis, and D.W. Owens. (1994). Genetic population survey of leatherbacks based onmtDNA. Page 36 in K.A. Bjorndal, A.B. Bolten, D.A. Johnson, and P.J. Eliazar, eds. Proceedingsof the Fourteenth Annual Symposium on Sea Turtle Biology and Conservation. NOAA TechnicalMemorandum NMFS-SEFSC-351.

Eckert, K.L. (1987). *Environmental unpredictability and leatherback sea turtle (Dermochelys coriacea) nest loss*, Herpetologica, vol. 43 no. 3, pp. 315-323 .

Eckert, K.L. (1993). *The biology and population status of marine turtles in the North Pacific Ocean*. (NOAA Technical Memorandum NMFS-SWFSC-186:1-156).

Eckert, K.L. (1995). *Leatherback Sea Turtle, Dermochelys coriacea*, in Status Reviews of Sea Turtles Listed under the Endangered Species Act of 1973, edited by P.T. Plotkin, pp. 37-75, U. S. National Marine Fisheries Service (U. S. Dept. Commerce), Silver Spring, Maryland (139 pp.) .

Eckert, K.L., K.A. Bjorndal, F.A. Abreu-Grobois, and M. Donnelly (eds.). (1999). *Research and Management Techniques for the Conservation of Sea Turtles*. IUCN/SSC Marine Turtle Specialist Group Publication No. 4. 235pp.

Eckert, S.A. (1998). *Perspectives on the use of satellite telemetry and other electronic technologies for the study of marine turtles, with reference to the first year long tracking of leatherback sea turtles*. In: Seventeenth Annual Sea Turtle Symposium, Vol. NOAA Tech. Memo NMFS-SEFSC-415 (ed. S.P. Epperly and J. Braun), pp. 294. U.S. Department of Commerce, National Oceanic and Atmospheric Agency, National Marine Fisheries Service, Orlando, Florida.

Eckert, S.A. (2002). Distribution of juevnile leatherback sea turtle (*Dermochelys coriacea*) sightings. Mar. Ecol. Prog. Ser. 230: 289–293.

Ehrhart, L.M., (1995). “A review of sea turtle reproduction,” pp. 29-38, In: K.A. Bjorndal, ed. *Biology and conservation of sea turtles, Rev. ed.* Washington, D.C.: Smithsonian Institution Press.

Ehrhart, L.M., D.A. Bagley, and W.E. Redfoot. (2003). Loggerhead Turtles in the Atlantic Ocean: Geographic Distribution, Abundance, and Population Status. Pages 157-174 *in* Bolten, A.B. and B.E. Witherington (editors).

Eldredge, L.G. (2003). The marine reptiles and mammals of Guam. Micronesica. 35-36:653-660.

Epperly, S.P., J. Braun, A.J. Chester, F.A. Cross, J.V. Merriner, and P.A. Tester. (1995). Winter distribution of sea turtles in the vicinity of Cape Hatteras and their interactions with the summer flounder trawl fishery. Bulletin of Marine Science 56:547-568.

Ernst, C.H., R.W. Barbour, and J.E. Lovich. (1994). Turtles of the United States and Canada. Washington, D.C.: Smithsonian Institution Press.

Frazier, J.G. (2001). General natural history of marine turtles. Pages 3-17 in K.L. Eckert and F.A. Abreu-Grobois, eds. Proceedings of the regional meeting: "Marine turtle conservation in the wider Caribbean region: a dialogue for effective regional management." Santo Domingo, Dominican Republic: WIDECAST, IUCN-MTSG, WWF, and UNEP-CEP

Godley, B.J., S. Richardson, A.C. Broderick, M.S. Coyne, F. Glen, & G.C. Hays. (2002). Long-term satellite telemetry of the movements and habitat utilisation by green turtles in the Mediterranean. *Ecography* 25(3):352-362.

Goertner, J.F. (1982). Prediction of underwater explosion safe ranges for sea mammals. *NSWC/WOL TR-82-188*. Naval Surface Weapons Center: White Oak Laboratory, Silver Spring, MD. 25 pp

Grant, G.S., and D. Ferrell. (1993). Leatherback turtle, *Dermochelys coriacea* (Reptilia: Dermochelyidae): Notes on near-shore feeding behavior associated with cobia. Brimleyana 19:77-81.

Gregory, J. and P. Schmid. 2001. Avoidance behaviour of *Alosa fallax fallax* to pulsed ultrasound and its potential as a technique for monitoring clupeid spawning migration in a shallow river. Aquatic Living Resources 16:313-316.

Gutierrez, J. (2004). *Guam sea turtle recovery annual progress report.* Mangilao, Guam: Guam Division of Aquatic and Wildlife Resources.

Hatase, H., K. Sato, M. Yamaguchi, K. Takahashi, and K. Tsukamoto. (2006). Individual variation in feeding habitat use by adult female green sea turtles (*Chelonia mydas*): Are they obligately neritic herbivores? Oecologia 149:52-64.

Hawai’i Department of Land and Natural Resources. (2002). *Application for an individual incidental take permit pursuant to the Endangered Species Act of 1973 for listed sea turtles in inshore marine fisheries in the main Hawaiian Islands managed by the State of Hawai’i*. Honolulu: Division of Aquatic Resources.

Hays, G.C., C.R. Adams, A.C. Broderick, B.J. Godley, D.J. Lucas, J.D. Metcalfe, & A.A. Prior. (2000). The diving behaviour of green turtles at Ascension Island. *Animal Behaviour* 59:577-586.

Hays, G.C., P. Luschi, F. Papi, C. Del Seppia, & R. Marsh. (1999). Changes in behaviour during the inter-nesting period and post-nesting migration for Ascension Island green turtles. *Marine Ecology Progress Series* 189:263-273.

Hays, G.C., J.D.R. Houghton, and A. Myers. (2004). Pan-Atlantic leatherback turtle movements. *Nature* 429: 522.

Hazel, J., I.R. Lawler, H. Marsh, & S. Robson. (2007). Vessel speed increases collision risk for the green turtle *Chelonia mydas*. *Endangered Species Research* 3:105–113.

Hirth, H.F. (1997). Synopsis of the biological data on the green turtle *Chelonia mydas* (Linnaeus 1758). U.S. Fish and Wildlife Service Biological Report 97(1):1-120.

Hochscheid, S., B.J. Godley, A.C. Broderick, & R.P. Wilson. (1999). Reptilian diving: Highly variable dive patterns in the green turtle *Chelonia mydas*. *Marine Ecology Progress Series* 185:101-112.

Holloway-Adkins, K. & J. Provancha. (2005). *Abundance and foraging activity of marine turtles using nearshore rock resources along the mid reach of Brevard County, Florida*. Prepared for Olsen Associates, Inc., Jacksonville, Florida by Dynamac Corporation, Cape Canaveral, Florida.

James, M.C., C.A. Ottensmeyer and R.A. Myers. 2006 Identification of high-use habitat and threats to leatherback sea turtles in northern waters: new directions for conservation. Ecology Letters 2005(8):195-201.

Jefferson Lab. (2007). *The ten most abundant elements in the Earth's crust*. Retrieved October 23, 2007 from http://education.jlab.org/glossary/abund_ele.html

Jessop, T.S., Knapp, R., Limpus, C.J., Whittier, J.M., (2002). “Dynamic endocrine responses to stress: evidence for energetic constraints and status dependence of breeding in male green turtles,” *Generaland Comparative. Endocrinology*, 126:59–67.

Kamezaki, N., Matsuzawa, K., Abe, O., Asakawa, H., Fuji, T., Goto, K. et al. (2003). Loggerhead turtles nesting in Japan. In: Loggerhead Sea Turtles (eds Bolten, A.B.and Witherington, B.E.). Smithsonian Institution Press, Washington, DC, pp. 210–217.

Kessler, C.C. & S.R. Vogt. (2002). *Report on attaching satellite transmitters to green sea turtles (Chelonia mydas) on Tinian, Commonwealth of the Northern Mariana Islands*. Prepared for Commander, U.S. Naval Forces Marianas: Environmental, Guam. Dededo, Guam: U.S. Fish and Wildlife Service.

Ketten, D.R. & S.M. Bartol. (2006). *Functional measures of sea turtle hearing*. ONR Award Number N00014-02-1-0510 Prepared for the Office of Naval Research: Arlington, Virginia by Woods Hole Oceanographic Institution, Woods Hole, Massachusetts.

Ketten, D.R. (1998). Marine mammal auditory systems: A summary of audiometric and anatomical data and its implications for underwater acoustic impacts. NOAA-TM-NMFS-SWFSC-256, Department of Commerce.

Kolinski, S.P., D.M. Parker, L.I. Ilo, & J.K. Ruak. (2001). An assessment of the sea turtles and their marine and terrestrial habitats at Saipan, Commonwealth of the Northern Mariana Islands. *Micronesia* 34(1):55-72.

Kolinski, S.P., L.I. Ilo, & J.M. Manglona. (2006). Green turtles and their marine habitats at Tinian and Aguijan, with projections on resident turtle demographics in the southern arc of the Commonwealth of the Northern Mariana Islands. *Micronesica* 37(1):97-118.

Lenhardt, M.L. (1994). Seismic and very low frequency sound induced behaviors in captive loggerhead marine turtles (*Caretta caretta*). Pages 238-241 in Bjorndal, K.A., A.B. Bolten, D.A. Johnson, and P.J. Eliazar, eds. *Proceedings of the Fourteenth Annual Symposium on Sea Turtle Biology and Conservation.* (NOAA Technical Memorandum NMFS-SEFSC-351).

Lenhardt, M.L. (2002). Sea turtle auditory behavior. Acoustical Society of America, 112(5):2314-2319

Lenhardt, M.L., S. Bellmund, R.A. Byles, S.W. Harkins, & J.A. Musick. (1983). Marine turtle reception of bone-conducted sound. *Journal of Auditory Research* 23:119-123.

Lewison, R.L., S.A. Freeman, and L.B. Crowder. (2004). Quantifying the effects of fisheries on threatened species: The impact of pelagic longlines on loggerhead and leatherback sea turtles. Ecology Letters 7:221-231.

Limpus, C.J.and D.J Limpus. (2003). The loggerhead turtle, *Caretta caretta*, in the Equatorial and Southern Pacific Ocean: a species in decline. In Loggerhead Sea Turtles (eds Bolten, A.B.and Witherington, B.E.). Smithsonian Institution Press, Washington, DC, pp. 199–209.

Lund, P.F. (1985). Hawksbill turtle (*Eretmochelys imbricata*) nesting on the east coast of Florida. *Journal of Herpetology* 19(1):164-166.

Lutcavage, M.E., P. Plotkin, B. Witherington, & P.L. Lutz. (1997). Human impacts on sea turtle survival. Pages 387-409 in Lutz, P.L. and J.A. Musick, eds. *The biology of sea turtles*. Boca Raton, Florida: CRC Press.

Márquez-M., R. (1990). Sea turtles of the world. An annotated and illustrated catalogue of sea turtle species known to date, Rome: Food and Agriculture Organization of the United Nations. FAO Fisheries Synopsis No 125, Volume 11, 4pp.

McEwen, B.S. and E.A. Lashley. (2002). *The end of stress as we know it*. Washington, DC: Joseph Henry Press. 239 pp.

Meylan, A.B. (1995). Sea turtle migration - evidence from tag returns. Pages 91-100 in K.A. Bjorndal, ed. Biology and conservation of sea turtles, Rev. ed. Washington, D.C.: Smithsonian Institution Press.

Meylan, A.B. & M. Donnelly. (1999). Status justification for listing the hawksbill turtle (*Eretmochelys imbricata*) as critically endangered on the 1996 IUCN Red List of Threatened Animals. *Chelonian Conservation and Biology* 3(2):200-224.

Meylan, A.B. (1988). Spongivory in hawksbill turtles: A diet of glass. *Science* 239:393-395.

Meylan, A.B. (1999). International movements of immature and adult hawksbill turtles (*Eretmochelys imbricata*) in the Caribbean region. *Chelonian Conservation and Biology* 3(2):189-194.

Michael, M. (2004). [Incidental observations of dolphins, whales, and turtles during scuba diving excursions off Rota. Received 10 December 2004 from Mr. Mark Michael, Dive Rota, Commonwealth of the Northern Mariana Islands]. Unpublished sighting data.

Moein Bartol, S. & D.R. Ketten. (2006). Turtle and tuna hearing. Pages 98-103 in Swimmer, Y. and R. Brill, eds. *Sea turtle and pelagic fish sensory biology: Developing techniques to reduce sea turtle bycatch in longline fisheries.* (NOAA Technical Memorandum NMFS-PIFSC-7).

Musick, J.A., and C.J. Limpus, (1997). "Habitat utilization and migration of juvenile sea turtles," pp. 137-163 In: P.L. Lutz and J.A. Musick, eds. *The biology of sea turtles*, CRC Press, Boca Raton, Florida.

National Marine Fisheries Service & U.S. Fish and Wildlife Service. (1993). *Recovery plan for hawksbill turtles in the U.S. Caribbean Sea, Atlantic Ocean, and Gulf of Mexico*. St. Petersburg, Florida: National Marine Fisheries Service.

National Marine Fisheries Service & U.S. Fish and Wildlife Service. (1998a). *Recovery plan for U.S. Pacific populations of the green turtle (*Chelonia mydas*)*. Silver Spring, Maryland: National Marine Fisheries Service.

National Marine Fisheries Service & U.S. Fish and Wildlife Service. (1998b). *Recovery plan for U.S. Pacific populations of the East Pacific green turtle (*Chelonia mydas*)*. Silver Spring, Maryland: National Marine Fisheries Service.

National Marine Fisheries Service & U.S. Fish and Wildlife Service. (1998c). *Recovery plan for U.S. Pacific populations of the Loggerhead Sea Turtle*. Silver Spring, Maryland: National Marine Fisheries Service.

National Marine Fisheries Service. (1993*). Endangered Species Act - Section 7 Consultation: Mine Warfare Training within Apra Harbor.* Biological Opinion.

National Marine Fisheries Service. (1998*). Endangered Species Act - Section 7 Consultation: Use of the Farallon de Medinilla live fire range by the U.S. Navy and other services*. Biological Opinion.

National Marine Fisheries Service. (2005*). Fisheries Reducing Bycatch 2005 Report.*

National Marine Fisheries Service. (2007*). Endangered Species Act - Section 7 Consultation: Valiant Shield 2007.* Biological Opinion.

National Research Council. (1990). *Decline of the sea turtles: Causes and prevention*. Washington, D.C.: National Academy Press.

NAVFACPAC (2008a). Micronesian Megapode (Megapodius laperouse laperouse) Surveys on Farallon de Medinilla, Commonwealth of the Northern Marianas Islands (DRAFT). Prepared by Scott Vogt, Wildlife Biologist. NAVFAC Pacific. Honolulu, Hawaii. April 2008.

NAVFACPAC (2008b). Wildlife Surveys on Military Leased Lands, Tinian, Commonwealth of the Northern Marianas Islands: Fiscal Years 2007 – 2008 Annual Report for 61755NR410 (DRAFT). Prepared by Scott Vogt, Wildlife Biologist. NAVFAC Pacific. Honolulu, Hawaii. April 2008.

NAVFACPAC (2008c). Wildlife Surveys on Military Leased Lands, Farallon de Meinilla, Commonwealth of the Northern Marianas Islands: Fiscal Years 2007 – 2008 Annual Report for 61755NR410 (DRAFT). Prepared by Scott Vogt, Wildlife Biologist. NAVFAC Pacific. Honolulu, Hawaii. April 2008.

O'Hara, J. & J.R. Wilcox. (1990). *Avoidance responses of loggerhead turtles, Caretta caretta, to low frequency sound.* Copeia 1990(2):564-567

Parker, G.L. (1995). Encounter with a juvenile hawksbill turtle offshore Sapelo Island, Georgia. *Marine Turtle Newsletter* 71:19-22.

Pickard, G. L., and W. J. Emery. (1982). *Descriptive Physical Oceanography: An Introduction*, 4th ed. Pergamon Press, New York.

Plotkin, P.T. (Editor). (1995). National Marine Fisheries Service and the U.S. Fish and Wildlife Service Status Reviews for Sea Turtles Listed Under the Endangered Species Act of 1973. National Marine Fisheries Service, Silver Spring, MD.

Plotkin, P.T., Byles, R.A. and Owens, D.W. (1994). Post breeding movements of male olive ridley sea turtles Lepidochelys olivacea from a nearshore breeding area. In Bjorndal, K.A., Bolten, A.B., Johnson, D.A., and Eliazar, P.J. (Compilers). *Proceedings of the Fourteenth Annual Symposium on Sea Turtle Biology and Conservation.* NOAA Technical Memorandum NMFS-SEFSC-351, p.119.

Polovina, J.J., D.R. Kobayashi, D.M. Parker, M.P. Seki, and G.H. Balazs. (2001). "Turtles on the edge: Movement of loggerhead turtles (*Caretta caretta*) along oceanic fronts, spanning longline fishing grounds in the central North Pacific, 1997-1998," *Fisheries Oceanography,* 9:71-82.

Polovina, J.J., G.H. Balazs, E.A. Howell, D.M. Parker, M.P. Seki, & P.H. Dutton. (2004). Forage and migration habitat of loggerhead (Caretta caretta) and olive ridley (Lepidochelys olivacea) sea turtles in the central North Pacific Ocean. *Fisheries Oceanography* 13(1):36-51.

Pritchard, P.C.H. (1995). Marine turtles of Micronesia. Pages 263-274 in K.A. Bjorndal, ed. *Biology and conservation of sea turtles*. Rev. ed. Washington, D.C.: Smithsonian Institution Press.

Pultz, S., D. O'Daniel, S. Krueger, H. McSharry, & G.H. Balazs. (1999). Marine turtle survey on Tinian, Mariana Islands. *Micronesica* 32(1):85-94.

Randall, R.H., R.T. Tsuda, R.S. Jones, M.J. Gawel, J.A. Chase, & R. Rechebei. (1975). *Marine biological survey of the Cocos Barrier Reefs and enclosed lagoon.* (University of Guam Marine Laboratory Technical Report No. 17). Submitted to USACE under contract DACW84-72-C-0015.

Ridgway, S.H., E.G. Wever, J.G. McCormick, J. Palin, & J.H. Anderson. (1969). Hearing in the giant sea turtle, *Chelonia mydas*. *Proceedings of the National Academy of Sciences of the United States of America* 64:884-890.

Romero, L. M. (2004). Physiological stress in ecology: lessons from biomedical research. *Trends in Ecology and Evolution* 19:249-255.

Salmon, M., T.T. Jones, & K.W. Horch. (2004). Ontogeny of diving and feeding behavior in juvenile seaturtles: Leatherback seaturtles (*Dermochelys coriacea* L) and green seaturtles (*Chelonia mydas* L) in the Florida Current. *Journal of Herpetology* 38(1):36-43.

Schroeder, B.A. & N.B. Thompson. (1987). Distribution of the loggerhead turtle, *Caretta caretta*, and the leatherback turtle, *Dermochelys coriacea*, in the Cape Canaveral, Florida area: Results of aerial surveys. Pages 45-53 in W.N. Witzell, ed. Proceedings of the Cape Canaveral, Florida Sea Turtle Workshop. NOAA Technical Report NMFS 53.

Schroeder, B.A., Foley, A.M., & Bagley, D.A. (2003). Nesting patterns, reproductive migrations, and adult foraging areas of loggerhead turtles. In: Bolten, A.B.,Witherington, B.E. (Eds.), Loggerhead Sea Turtles. Smithsonian Books,Washington, pp. 114–124.

Seminoff, J.A. & Marine Turtle Specialist Group: Green Turtle Task Force. (2004). *Marine Turtle Specialist Group review: 2004 global status assessment, green turtle (Chelonia mydas)*. Prepared for The World Conservation Union Species Survival Commission Red List Authority.

Seminoff, J.A., W.J. Nichols, A. Resendiz, & L. Brooks. (2003). Occurrence of hawksbill turtles, Eretmochelys imbricata (Reptilia: Cheloniidae), near the Baja California Peninsula, Mexico. *Pacific Science* 57(1):9-16.

Shoop, C.R. & R.D. Kenney. (1992). Seasonal distributions and abundances of loggerhead and leatherback sea turtles in waters of the northeastern United States. Herpetological Monographs 6:43-67.

Snover, M. (2005). "Population trends and viability analyses for Pacific Marine Turtles," U.S. Department of Commerce, National Oceanic and Atmospheric Administration, National Marine Fisheries Service, *Pacific Islands Fishery Science Center Internal Report IR-05- 008*. Honolulu, Hawaii.

Spargo, B. (2007). Personal communication between Dr. Barry Spargo, Naval Research Laboratory, and Mark Collins, Parsons, June 1, 2007.

Spotila, J.R. (2004). Thermal biology. Pages 297-314 in P.L. Lutz and J.A. Musick, eds. The biology of sea turtles. Boca Raton, Florida: CRC Press.

U.S. Air Force. (1997). *Environmental Effects of Self-Protection Chaff and Flares, Final Report*. U.S. Air Force Combat Command: Langley Air Force Base, VA.

U.S. Department of the Navy. (1996). *Draft Environmental Assessment of the Use of Selected Navy Test Sites for Development Tests and Fleet Training Exercises of the MK 46 and MK 50 Torpedoes.* Program Executive Office Undersea Warfare, Program Manager for Undersea Weapons.

U.S. Department of the Navy. (1998a). *Pacific Missile Range Facility Enhanced Capability Final Environmental Impact Statement.* December 1998.

U.S. Department of the Navy. (1998b). *Shock Testing the SEAWOLF Submarine Final Environmental Impact Statement.* May 1998.

U.S. Department of the Navy. (2000). *Noise blast test results aboard USS Cole. 8000 Ser G70/132.* Report from Commander, Dahlgren Division, Naval Surface Warfare Center, Dahlgren, Virginia to Commander-in Chief, U.S. Atlantic Fleet (N3).

U.S. Department of the Navy. (2001a). Integrated Natural Resources Management Plan: Navy Lands, Guam. Commander, U.S. Naval Forces Marianas, 19 November 2001.

U.S. Department of the Navy. (2001b). *Environmental Impact Statement for the Shock Trial of the Winston S. Churchill,* (DDG-81), Department of the Navy.

U.S. Department of the Navy. (2003a*). Integrated Natural Resources Management Plan: Farallon de Medinilla and Tinian Military Lease Areas, Commonwealth of the Northern Marianas Islands*. Prepared for Commander, U.S. Naval Forces Marianas, by Helber Hastert and Fee, Planners. November 2003.

U.S. Department of the Navy. (2003b). Year 2002 assessment of marine and fisheries resources: Farallon de Medinilla, Commonwealth of the Northern Mariana Islands. Final report. Contract N62742-99-D-1807; DO 0026. Prepared by Belt Collins Hawaii, Honolulu, Hawaii.

U.S. Department of the Navy. (2004). Year 2003 assessment of marine and fisheries resources---Farallon de Medinilla, Commonwealth of the Northern Mariana Islands. Final report. Submitted to Pacific Division, Naval Facilities Engineering Command, Pearl Harbor, Hawaii, under contract no. N62742-02-D-1802, DO 002, by the Environmental Company, Honolulu, Hawaii.

U.S. Department of the Navy. (2005a). Marine Resources Assessment for the Marianas Operating Area. Department of the Navy, Commander. U.S. Pacific Fleet. 416 pp.

U.S. Department of the Navy. (2005b). Tinian sea turtle nesting data. Received 11 April 2005 from Scott Vogt, Biologist, Naval Facilities Engineering Command Pacific, Pearl Harbor, Hawaii.

U.S. Department of the Navy. (2006a). 2006 Supplement to the 2002 RIMPAC Programmatic Environmental Assessment. Department of the Navy, Commander, Third Fleet.

U.S. Department of the Navy. (2006b). Undersea Warfare Exercise (USWEX) EA/OEA. Department of the Navy, Commander, Third Fleet.

U.S. Department of the Navy. (2006c). Final comprehensive overseas environmental assessment for major Atlantic Fleet training exercises. Prepared for United States Fleet Forces Command, Norfolk, Virginia by Naval Facilities Engineering Command, Atlantic, Norfolk, Virginia.U.S. Fish and Wildlife Service & National Marine Fisheries Service. (1998). *Endangered Species Consultation Handbook, Procedures for Conducting Consultations and Conference Activities under Section 7 of the Endangered Species Act.*

U.S. Fish and Wildlife Service. (2006a). Green Sea Turtle Fact Sheet. On-line at www.fws.gov.

U.S. Fish and Wildlife Service. (2006b). Hawksbill Sea Turtle Fact Sheet. On-line at www.fws.gov.

U.S. Fish and Wildlife Service. (2006c). Loggerhead Sea Turtle Fact Sheet. On-line at www.fws.gov.

U.S. Fish and Wildlife Service. (2006d). Olive Ridley Sea Turtle Fact Sheet. On-line at www.fws.gov.

Wiles, G.J., A.B. Amerson, Jr. & R.E. Beck, Jr. (1989). Notes on the herpetofauna of Tinian, Mariana Islands. *Micronesica* 22(1):107-118.

Wiles, G.J., C.F. Aguon, G.W. Davis, & D.J. Grout. (1995). The status and distribution of endangered animals and plants in northern Guam. *Micronesica* 28(1):31-49.

Wiles, G.J., G.H. Rodda, T.H. Fritts, & E.M. Taisacan. (1990). Abundance and habitat use of reptiles on Rota, Mariana Islands. *Micronesica* 23(2):153-166.

Witherington, B. & S. Hirama. (2006). Sea turtles of the epi-pelagic sargassum drift community. Page 209 in *Abstracts, Twenty-sixth Annual Symposium on Sea Turtle Biology and Conservation*. 3-8 April 2006. Island of Crete, Greece.

Witherington, B., M. Bresette, & R. Herren. (2006a). *Chelonia mydas* - green turtle. Pages 90-104 in Meylan, P.A., ed. *Biology and conservation of Florida turtles*. Chelonian Research Monographs No. 3. Lunenburg, Massachusetts: Chelonian Research Foundation.

Witzell, W.N. (1983). Synopsis of biological data on the hawksbill turtle *Eretmochelys imbricata* (Linnaeus 1766). FIR/S137. *FAO Fisheries Synopsis* 137:1-78.

Wyneken, J. (1997). *Sea turtle locomotion: Mechanics, behavior, and energetics*. Pages 165-198 in P.L. Lutz and J.A. Musick, eds. The biology of sea turtles. Boca Raton, Florida: CRC Press.

Section 3.9 References: Fish and Essential Fish Habitat

Abbott, R., J. Reyff, & G. Marty, (2005). *Monitoring the effects of conventional pile driving on three species of fish.* Final report prepared by Strategic Environmental Consulting, Inc. for Manson Construction Company: Richmond, California.

Abbott, R. & E. Bing-Sawyer. (2002). *Assessment of Pile-Driving Impacts on the Sacramento Blackfish (Othodon microlepidotus).* Draft report prepared for the California Department of Transportation, District 4.

Amesbury, S.S., F.A. Cushing, & R.K. Sakamoto. (1986). *Guide to the coastal resources of Guam. Volume 3: Fishing on Guam.* Mangilao, Guam: University of Guam Press.

Amoser, S. & F. Ladich. (2003). Diversity in noise-induced temporary hearing loss in tophysine fishes. *Journal of the Acoustical Society of America,* 113(4): 2170-2179, part.

Amoser, S. & F. Ladich. (2005). Are hearing sensitivities of freshwater fish adapted to the ambient noise in their habitats? *Journal of Experimental Biology,* 208: 3533-3542.

Astrup, J. (1999). Ultrasound detection in fish - a parallel to the sonar-mediated detection of bats by ultrasound-sensitive insects? *Comparative Biochemistry and Physiology, Part A,* 124:19-27.

Astrup, J. & Møhl, B. (1993). Detection of intense ultrasound by the cod *Gadus morhua. Journal of Experimental Biology,* 182: 71-80.

Atema, J., R.R. Fay, A.N. Popper, & W.N. Tavolga eds. (1988). Sensory Biology of Aquatic Animals. New York: Springer Verlag.Au, W.W.L., 1993. *The sonar of dolphins, Springer-Verlag,* New York, 277 pp.

Banner, A., & M. Hyatt. (1973). Effects of noise on eggs and larvae of two estuarine fishes. *Transactions of the American Fisheries Society,* 102(1):134-136.

Baxter, L. II, E.E. Hays, G.R. Hampson, & R.H. Backus. (1982). Mortality of fish subjected to explosive shock as applied to oil well severance on Georges Bank. *Woods Hole Oceanographic Institution Report WHO-82-54.*

Bennett, D.H, C.M. Falter, S.R. Chipps, K. Niemela, & J. Kinney. (1994). *Effects of underwater sound stimulating the intermediate scale measurement system on fish and zooplankton of Lake Pend Oreille, Idaho.* (Research Report prepared by College of Forestry, Wildlife and Range Sciences, University of Idaho for Office of Naval Research, Arlington Virginia). Contract N00014-92-J-4106.

Bellwood, O. (2002). The occurrence, mechanics and significance of burying behaviour in crabs (Crustacea: Brachyura). *Journal of Natural History* 36:1223-1238.

Booman, C., H. Dalen, H. Heivestad, A. Levsen, T. van der Meeren, & K. Toklum. (1996). Effekter av luftkanonskyting pa egg, larver og ynell. *Havforskningsinstituttet, Issn* 0071- 5638.

Buerkle, U. (1968). Relation of pure tone thresholds to background noise level in the Atlantic cod (*Gadus morhua*). *Journal of the Fisheries Research Board of Canada,* 25: 1155 1160.

Buerkle, U. (1969). Auditory masking and the critical band in Atlantic cod (*Gadus morhua*). *Journal of the Fisheries Research Board of Canada*, 26:1113 1119.

Caltrans. (2001). *Pile Installation Demonstration Project, Fisheries Impact Assessment PIDP EA 012081*. Caltrans Contract 04A0148. San Francisco - Oakland Bay Bridge East Span Seismic Safety Project.

Caltrans. (2004). *Fisheries and Hydroacoustic Monitoring Program Compliance Report for the San Francisco-Oakland Bay Bridge East Span Seismic Safety Project*. Prepared by Strategic Environmental Consulting, Inc. and Illingworth & Rodkin, Inc. June.

Casper, B.M. & D.A. Mann. (2006). Evoked potential audiograms of the nurse shark (*Ginglymostoma cirratum*) and the yellow stingray (*Urobatis jamaicensis*). *Environmental Biology of Fishes*, 76:101–108.

Casper, B.M., P.S. Lobel, & H.Y. Yan. (2003). The hearing sensitivity of the little skate, *Raja erinacea*: A comparison of two methods. *Environmental Biology of Fishes* 68: 371-379.

Cato, D.H. (1978). Marine biological choruses observed in tropical waters near Australia. *Journal of the Acoustical Society of America*, 64(3), 736-743. (Chapman, 1973).

Chapman, C.J. & A.D. Hawkins. (1969). The importance of sound in fish behaviour in relation to capture by trawls. *FAO Fisheries Report* 62(3): 717-729.

Chapman C.J & A.D. Hawkins. (1973). A field study of hearing in the cod, Gadus morhua. *Journal of Comparative Physiology* 85:147 167.

Coker, C.M. & E.H. Hollis. (1950). Fish mortality caused by a series of heavy explosions in Chesapeake Bay. *Journal of Wildlife Management* 14(4): 435-445.

Collin, S.P. & N.J. Marshall. (2003). *Sensory Processing in Aquatic Environments*. New York: Springer-Verlag.

Corwin J.T. (1981). Audition in elasmobranchs. pp. 81-105. In: *Hearing and Sound Communication in Fishes*, eds. W.N. Tavolga, A.N. Popper, & R.R. Fay, New York: Springer Verlag.

Corwin J.T. (1989). Functional anatomy of the auditory system in sharks and rays. *Journal of Experimental Zoology, Supplement*, 2:62-74.

Culik, B.M., S. Koschinski, N. Tregenza, & G.M. Ellis. (2001). Reactions of harbour porpoises (*Phocoena phocoena*) and herring (*Clupea harengus*) to acoustic alarms. *Marine Ecology Progress Series* 211:255-260.

Dalen J & A. Raknes. (1985). Scaring effects on fish from three-dimensional seismic surveys. *Report No. FO 8504*. Institute of Marine Research. Bergen, Norway.

Dalen, J. & G.M. Knutsen. (1986). Scaring effects in fish and harmful effects on eggs, larvae and fry by offshore seismic exploration. pp. 93-102. In: Merklinger, H.M. (Ed.), *Progress in Underwater Acoustics*. Plenum Press, New York.

Dijkgraaf, S. (1952). Uber die Schallwahrnehmung bei Meeresfischen. *Zeitschrift verglishende Phyiologie,* 34:104-122.

Dunning, J.B., B.J. Danielson, & H.R. Pulliam. (1992). Ecological processes that affect populations in complex landscapes. *Oikos,* 65:169-175.

Dwyer, W.P., W. Fredenberg, & D.A. Erdahl. (1993). Influence of electroshock and mechanical shock on survival of trout eggs. *North American Journal of Fisheries Management* 13:839-843.

Edds-Walton, P.L. & J.J. Finneran. (2006). *Evaluation of evidence for altered behavior and auditory deficits in fishes due to human-generated noise sources.* (SPAWAR Technical Report 1939). 50 pp.

Engas, A., S. Lokkeborg, E. Ona, & A.V. Soldal. (1996). Effects of seismic shooting on local abundance and catch rates of cod (*Gadus morhua*) and haddock (*Melanogrammus aeglefinus*). *Canadian Journal of Fisheries Aquatic Science,* 53: 2238-2249. (2)

Enger, P.S. (1967). Hearing in herring. *Comparative Biochemistry and Physiology* 22:527 538.

Enger, P.S. (1981). Frequency discrimination in teleosts-central or peripheral? pp. 243-255. In: *Hearing and Sound Communication in Fishes,* eds. W.N. Tavolga, A.N. Popper, & R.R. Fay. New York: Springer-Verlag.

Fay, R.R. (1988). *Hearing in vertebrates: a psychophysics data book*. Hill-Fay Associates, Winnetka, Illinois. 630 pp.

Fay, R.R. (2005). Sound source localization by fishes. pp 36-66. In: *Sound Source Localization*, eds. A.N. Popper and R.R. Fay. New York: Springer Science + Business Media, LLC.

Fay, R.R. & Megela-Simmons A. (1999). The sense of hearing in fishes and amphibians. pp. 269-318. In: *Comparative Hearing: Fish and Amphibians,* eds. R.R. Fay and A.N. Popper. New York: Springer-Verlag.

Fish, J.F. & C.W. Turl. (1976). *Acoustic source levels of four species of small whales*. (Naval Undersea Center Report, NUC-TP 547).

Fish, J.F. & G.C. Offutt. (1972). Hearing thresholds from toadfish, *Opsanus tau,* measured in the laboratory and field. *Journal of the Acoustic Society of America,* 51:1318-1321.

Froese, R. & D. Pauly, eds. (2004). *FishBase*. World Wide Web Electronic Publication. Retrieved November 23, 2004 from http://www.fishbase.org/search.cfm

Gaspin, J.B. (1975). *Experimental investigations of the effects of underwater explosions on swimbladder fish, I: 1973 Chesapeake Bay tests*. (Naval Surface Weapons Center Report NSWC/WOL/TR 75-58).

Gausland, I. (2003). *Seismic survey impact on fish and fisheries*. Report prepared by Stavanger for Norwegian Oil Industry Association.

Gearin, P.J., M.E. Gosho, J.L. Laake, L. Cooke, R.L. DeLong, & K.M. Hughes. (2000). Experimental testing of acoustic alarms (Pingers) to reduce bycatch of harbour porpoise, *Phocoena phocoena*, in the State of Washington. *Journal of Cetacean Research and Management 2:1-9.*

Goertner, J.F. (1982). *Prediction of underwater explosion safe ranges for sea mammals*. (NSWC/WOL TR-82-188). Naval Surface Weapons Center: White Oak Laboratory, Silver Spring, MD, 25 pp.

Goertner, J.F., M.L. Wiley, G.A. Young, & W.W. McDonald. (1994). *Effects of underwater explosions on fish without swimbladders.* (Naval Surface Warfare Center Report NSWC TR88-114). 113 pp.Geortner *et al.* 1994.

Goldman, K.J. & B. Human. (2000). *Lamna ditropis*. In: *IUCN 2004*. 2004 IUCN red list of threatened species retrieved November 16, 2004 from http://www.redlist.org

Goldman, K.J. & members of the Shark Specialist Group. (2001). *Alopias vulpinus*. 2003 IUCN Red List of Threatened Species retrieved November 16, 2004 from http:// www.redlist.org

Govoni, J.J., L.R. Settle, & M.A. West. (2003). Trauma to juvenile pinfish and spot inflicted by submarine detonations. *Journal of Aquatic Animal Health*. 15:111-119.

Gregory, J. & Clabburn, P.A.T. (2003). Avoidance behaviour of *Alosa fallax* to pulsed ultrasound and its potential as a technique for monitoring clupeid spawning migration in a shallow river. *Aquatic Living Resources*, 16:313-316.

Halvorsen, M.B., L.E. Wysocki, & A.N. Popper. (2006). Effects of high-intensity sonar on fish. *Journal of the Acoustical Society of America* 119:3283.

Hastings, M.C. & Popper, A.N. (2005). *Effects of sound on fish*. (Technical report for Jones and Stokes to California Department of Transportation, Sacramento, CA). [Online].

Hastings, M.C., Popper, A.N., Finneran, J.J. & Lanford, P.J. (1996). Effects of low-frequency underwater sound on hair cells of the inner ear and lateral line of the teleost fish (*Astronotus ocellatus*). *Journal of the Acoustical Society of America* 99:1759-1766.

Hawkins, A.D. & A.D.F. Johnstone. (1978). The hearing of the Atlantic salmon, *Salmo salar*. *Journal of Fish Biology* 13: 655-673.

Helfman, G.S., Collette, B.B., & D.E. Facey. (1999). *The diversity of fishes*. 4th ed. Malden, Massachusetts: Blackwell Science.

Higgs, D.M., 2005. Auditory cues as ecological signals for marine fishes. In: Weissburg MJ, Browman HI (eds) Sensory biology: linking the internal and external ecologies of marine organisms. *Marine Ecology Program Seried* 287:278–307.

Higgs, D.M., Plachta, D.T.T., Rollo, A.K., Singheiser, M., Hastings, M.C. & Popper, A.N. (2004). Development of ultrasound detection in American shad (*Alosa sapidissima*). *Journal of Experimental Biology,* 207, 155–163.

Holthuis, L.B. (1991). FAO species catalogue. Volume 13: Marine lobsters of the world. An annotated and illustrated catalogue of species of interest to fisheries known to date. *FAO Fisheries Synopsis No. 125, Vol. 13*. Rome, Italy: Food and Agriculture Organization.

Idechong, G. Paulay, A. Tafileichig, & N. Vander Velde. (2002). *The State of Coral Reef Ecosystems of the United States and Pacific Freely Associated States: 2002*. Silver Spring, Maryland: National Oceanic and Atmospheric Administration: National Ocean Service, National Centers for Coastal Ocean Science.

International Union for Conservation of Nature and Natural Resources. (2004). *2004 IUCN red list of threatened species* retrieved November 29, 2004 from http://www.redlist.org

Iversen, R.T.B. (1967). Response of the yellowfin tuna (*Thunnus albacares*) to underwater sound. pp. 105-121. In: W.N. Tavolga (editor), *Marine Bio-Acoustics II*. Pergamon Press, New York.

Iversen, R.T.B. (1969). Auditory thresholds of the scombrid fish *Euthynnus affinis*, with comments on the use of sound in tuna fishing. Proceedings of the FAO Conference on Fish Behaviour in Relation to Fishing Techniques and Tactics, October 1967. *FAO Fisheries Reports* No. 62 Vol. 3. FRm/R62.3.

Jensen, J.O.T. & D.F. Alderdice. (1983). Changes in mechanical shock sensitivity of coho salmon (*Oncorhyncuus kisutch*) eggs during incubation. *Aquaculture*, 32:303-312.

Jensen, J.O.T. & D.F. Alderdice. (1989). Comparison of mechanical shock sensitivity of eggs of five Pacific salmon (Oncorhyncus) species and steelhead trout (*Salmo gairdneri*). *Aquaculture*, 78:163-181.

Jorgensen, R, K.K. Olsen, I-B Falk-Petersen, & P. Kanapthippilai. (2005). *Investigations of potential effects of low frequency sonar signals on survival, development and behavior of fish larvae and juveniles*. Norwegian College of Fishery Science, University of Tromso, N-9037, Norway.

Kalmijn, A.J. (1988). Hydrodynamic and acoustic field detection. pp. 83-130. In: *Sensory Biology of Aquatic Animals*, eds. A. Atema, R.R. Fay, A.N. Popper, & W.N. Tavolga, New York: Springer-Verlag.

Kalmijn, A.J. (1989). Functional evolution of lateral line and inner ear sensory systems. pp. 187- 215. In: *The mechanosensory lateral line - Neurobiology and evolution*, eds. S. Coombs, P. Görner, and M. Münz. Berlin: Springer Verlag.

Karlsen, H.E. (1992). Infrasound sensitivity in the plaice (*Pleuronectes plattessa*). *Journal of Experimental Biology*, 171:173-187. Keevin *et al*. 1997.

Keevin, T.M., G.L. Hempen, & D.J. Schaeffer. (1997). Use of a bubble curtain to reduce fish mortality during explosive demolition of Locks and Dam 26, Mississippi River. pp. 197- 206. In: *Proceedings of the Twenty-third Annual Conference on Explosives and Blasting Technique*, Las Vegas, Nevada, International Society of Explosive Engineers, Cleveland, Ohio.

Kenyon, T.N. (1996). Ontogenetic changes in the auditory sensitivity of damselfishes (Pomacentridae). *Jounal of Comparative Physioogyl A*, 179:553–561.

Knudsen, F.R., P.S. Enger, & O. Sand. (1992). Awareness reactions and avoidance responses to sound in juvenile Atlantic salmon, *Salmo salar L. Journal of Fish Biology.*

Knudsen, F.R., P.S. Enger, & O. Sand. (1994). Avoidance responses to low frequency sound in downstream migrating Atlantic salmon smolt, *Salmo salar L. Journal of Fish Biology,* 45:227-233.

Kostyuchenko, L.P. (1973). Effects of elastic waves generated in marine seismic prospecting on fish eggs in the Black Sea. *Hydrobiologia*, 9:45-46.

Kvadsheim, PH & E.M. Sevaldsen. (2005). *The potential impact of 1 – 8 kHz active sonar on stocks of juvenile fish during sonar exercises.* Forsvarets Forskningsinstitutt, PO Box 25, NO-2027, Kjeller, Norway (FFI/Rapport-2005/01027).

Ladich, F. & A.N. Popper. (2004). Parallel evolution in fish hearing organs. pp. 95-127. In: Manley, G.A., A.N. Popper, & R.R. Fay (eds), *Evolution of the Vertebrate Auditory System.* Springer Handbook of Auditory Research. Springer-Verlag, New York.

Lombarte, A. & A.N. Popper, (1994). Quantitative analyses of postembryonic hair cell addition in the otolithic endorgans of the inner ear of the European hake, *Merluccius merluccius* (Gadiformes, Teleostei). *Journal of Comparative Neurology,* 345:419-428.

Lombarte, A, H.Y. Yan, Popper, A.N., J.C. Chang, & C. Platt. (1993). Damage and regeneration of hair cell ciliary bundles in a fish ear following treatment with gentamicin. *Hearing Research,* 66:166-174.

Lovell, J.M., M.M. Findlay, R.M. Moate, & D.A. Pilgrim. (2005). The polarization of inner ear ciliary bundles from a scorpaeniform fish. *Journal of Fish Biology* 66: 836–846.

Løvik, A. & J.M. Hovem. (1979). An experimental investigation of swimbladder resonance in fishes. *Journal of the Acoustical Society of America*, 66: 850-854.

Luczkovich, J.J., Daniel, H.J., III, Hutchinson, M., Jenkins, T., Johnson, S.E., Pullinger, R.C. & Sprague, M.W. (2000). Sounds of sex and death in the sea: bottlenose dolphin whistles suppress mating choruses of silver perch. *Bioacoustics* 10 (4) pp. 323-334.

Mann, D.A. & Lobel, P.S. (1997). Propagation of damselfish (Pomacentridae) courtship sounds. *Journal of the Acoustical Society of America,* 101: 3783–3791,

Mann, D.A., D.M. Higgs, W.N. Tavolga, M.J. Souza, & A.N. Popper. (2001). Ultrasound detection by clupeiform fishes. *Journal of the Acoustical Society of America* 109:3048- 3054.

Mann, D.A., Z. Lu, & A.N. Popper. (1997). A clupeid fish can detect ultrasound. *Nature* 389: 341.

Mann, D.A., Z. Lu, M.C. Hastings, & A.N. Popper. (1998). Detection of ultrasonic tones and simulated dolphin echolocation clicks by a teleost fish, the American shad (*Alosa sapidissima). Journal of the Acoustical Society of America* 104:562-568.

Mann, M.E., Rutherford, S., Wahl, E., & C. Ammann. (2005). Testing the fidelity of methods used in proxy-based reconstructions of past Climate. *Journal of Climate* 18“4097-4107.

McCartney, B.S. & A.R. Stubbs. (1971). Measurements of the acoustic target strengths of fish in dorsal aspect, including swimbladder resonance. *Journal of Sound and Vibration* 15:397-420.

McCauley, R.D. & D.H. Cato. (2000). Patterns of fish calling in a nearshore environment in the Great Barrier Reef. In: *Philosophical Transactions of the Royal Society Biological Sciences*. Volume 355, No. 1401/September 20, 2000.

McCauley, R.D., J. Fewtrell & A.N. Popper. (2003). High intensity anthropogenic sound damages fish ears. *Journal of the Acoustical Society of America* 113(1):638-642.

McCauley, R.D., M.N. Jenner, C. Jenner, K.A. McCabe, & J. Murdoch. (1998). The response of humpback whales (*Megaptera novaeangliae*) to offshore seismic survey noise: preliminary results of observations about a working seismic vessel and experimental exposures. *APPEA Journal* 38:692-707.

Mills, J.H., R.M. Gilbert, & W.Y. Adkins. (1979). Temporary threshold shifts in humans exposed to octave bands of noise for 16 to 24 hours. *Journal of the Acoustical Society of America* 65:1238–1248. (Moffitt, 1993).

Myers, R. (1999). *Micronesian reef fishes: A comprehensive guide to the coral reef fishes of Micronesia*. 3d ed. Barrigada, Territory of Guam: Coral Graphics.

Myers, R.F. & T.J. Donaldson. (2003). The fishes of the Marianas Islands. *Micronesica* 35-36:594-648.

Myrberg , A.A., Jr., A. Banner, & J.D. Richard. (1969). Shark attraction using videoacoustic system. *Marine Biology* 2:264.

Myrberg , A.A., Jr., C.R. Gordon, & A.P. Klimley. (1976). Attraction of free ranging sharks by low frequency sound, with comments on its biological significance. pp. 205-228. In: *Sound Reception in Fish*, eds. A. Schuijf and A.D. Hawkins, 205-228. Amsterdam: Elsevier.

Myrberg , A.A., Jr., S.J. Ha, S. Walewski, & J.C. Banbury. (1972). Effectiveness of acoustic signals in attracting epipelagic sharks to an underwater sound source. *Bulletin of Marine Science* 22:926-949.

Myrberg, A.A. Jr. (2001). The acoustical biology of elasmobranches. *Environmental Biology of Fishes* 60: 31-45.

Myrberg, A.A., Jr. & J.Y. Spires. (1980). Hearing in damselfishes: an analysis of signal detection among closely related species. *Journal of Comparative Physiology* 140:135-144.

National Marine Fisheries Service. (1996). *Our Living Oceans: Economic status of the U.S. fisheries 1996*. Silver Spring, Maryland: National Marine Fisheries Service.

National Marine Fisheries Service. (2002). *Fisheries off west coast states and in the western Pacific; Atlantic highly migratory species; Fisheries of the northeastern United States; Implementation of the Shark Finning Prohibition Act*. Federal Register 67(28):6194-6202.

National Marine Fisheries Service. (2003a). *Annual report to Congress on the status of U.S. fisheries - 2002*. Silver Spring, Maryland: National Marine Fisheries Service.

National Marine Fisheries Service. (2003b). *Draft Environmental Impact Statement: Bottomfish and seamount groundfish fisheries in the western Pacific region*. Honolulu, Hawaii: Western Pacific Regional Fishery Management Council.

National Marine Fisheries Service. (2003c). *2003 Guam/Marianas fishing derby* retrieved August 15, 2005 from http://www.pifsc.noaa.gov/wpacfin/guam/dawr/Pages/gdawr_dawr_3.htm

National Marine Fisheries Service-Pacific Islands Region. (2004). *Draft environmental impact statement, seabird interaction mitigation methods under the Fishery Management Plan Pelagics Fisheries of the Western Pacific Region and pelagic squid fishery management under the Fishery Management Plan Pelagics Fisheries of the Western Pacific Region and the High Seas Fishing Compliance Act*. Honolulu, Hawaii: National Marine Fisheries Service, Pacific Islands Regional Office.

National Marine Fisheries Service. (2004a). *Annual report to Congress on the status of U.S. fisheries--200*3. Silver Spring, Maryland: National Marine Fisheries Service.

National Marine Fisheries Service. (2004b). *Fisheries off the west coast states and in the Western Pacific; Western Pacific pelagic fisheries; highly migratory species fisheries; overfishing determination for bigeye tuna*. Federal Register 69(250):78397-78398.

National Marine Fisheries Service. (2004c). *National Marine Fisheries Service Office of Protected Resources* retrieved November 30, 2004 from http://www.nmfs.noaa.gov/pr/species/concern

National Marine Fisheries Service. (2004d). *Endangered Species Act section 7 consultation on proposed regulatory amendments to the FMP for the pelagic fisheries of the western Pacific region.* Biological Opinion.

National Oceanic and Atmospheric Administration. (2002). *Final Rule SURTASS LFA Sonar*. Department of Commerce; NMFS, Federal Register, Vol 67, No. 136, pp. 46712-46789.

Nedwell J.R., A.W.H. Turnpenny, J. Gordon, & B. Edwards. (2006). Fish and marine mammal audiograms: a summary of available information on their hearing. *Subacoustech Report to the Department of Trade and Industry Reference:* 534R0210 (307 pp., in preparation).

Nedwell, J.R., B. Edwards, A.W.H. Turnpenny, & J. Gordon. (2004). Fish and marine mammal audiograms: A summary of available information. *Subacoustech Limited., Report*, Reference 534R0214.

Nelson, D. R. (1967). Hearing thresholds, frequency discrimination and acoustic orientation in the lemon shark, *Negaprion brevirostris*, (Poey). *Bulletin of Marine Science* 17:741- 768.

Nelson, D.R. & R.H. Johnson. (1972). Acoustic attraction of Pacific reef sharks: effect of pulse intermittency and variability. *Comparative Biochemistry and Physiology-Part A* 42:85-95. (Nestler *et al*. 2002).

O'Keeffe, D. J. & G. A. Young. (1984). *Handbook on the environmental effects of underwater explosions*. Naval Surface Weapons Center: Dahlgren, Virginia 22448. (Report No. NSWC TR 83-240).

Oxman, D.S., R. Barnett-Johnson, M.E. Smith, A.B. Coffin, D.D. Miller, R. Josephson, & A.N. Popper. (2007). The effect of vaterite deposition on otolith morphology, sound reception and inner ear sensory epithelia in hatchery-reared chinook salmon (*Oncorhynchus tshawytscha*). *Canadian Journal of Fisheries and Aquatic Sciences,* 64:1469-1478.

Paulay, G., R. Knopp, P.K.L. Ng, & L.G. Eldredge. (2003). The crustaceans and pycnogonids of the Mariana Islands. *Micronesica* 35-36:456-513.

Pearson, W.H., J.R. Skalski, & C.I. Malme. (1987). *Effects of sounds from a geophysical survey device on fishing success*. (Report prepared by Battelle/Marine Research Laboratory for the Marine Minerals Service: United States Department of the Interior under Contract Number 14-12-0001-30273).

Pearson, W.H., J.R. Skalski, & C.I. Malme. (1992). Effects of sounds from a geophysical survey device on behavior of captive rockfish (*Sebastes* ssp). *Canadian Journal Fisheries and Aquatic Science* 49:1343-1356.

Pickering, A.D. (1981). *Stress and Fishes*. New York: Academic Press.

Pitcher, C.R. (1993). Spiny lobster. Pages 539-607 in A. Wright and L. Hill, eds. *Nearshore marine resources of the South Pacific: Information for fisheries development and management*. Suva, Fiji: Institute of Pacific Studies; and Honiara, Solomon Islands: Forum Fisheries Agency.

Plachta, D.T.T. & A.N. Popper. (2003). Evasive responses of American shad (*Alosa sapidissima*) to ultrasonic stimuli. *Acoustic Research Letters Online 4: 25-30, 2003* [Online]. Available: http://scitation.aip.org/getpdf/servlet/GetPDFServlet?filetype= pdf&id=ARLOFJ000004000002000025000001&idtype=cvips&prog=normal

Plachta, D.T.T., J. Song , M.B. Halvorsen, & A.N. Popper. (2004). Neuronal encoding of ultrasonic sound by a fish. *Journal of Neurophysiology* 91:2590-2597.

Polovina, J.J. (1993). The lobster and shrimp fisheries in Hawaii. *Marine Fisheries Review* 55(2):28-33.

Popper, A.N. (1977). A scanning electron microscopic study of the sacculus and lagena in the ears of fifteen species of teleost fishes. *Journal of Morphology* 153:397-418.

Popper, A.N. (1980). Scanning electron microscopic study of the sacculus and lagena in several deep-sea fishes. *American Journal of Anatomy* 157:115-136.

Popper, A.N. (1981). Comparative scanning electron microscopic investigations of the sensory epithelia in the teleost. *Journal of Comparative Neurology* 200:357-374.

Popper, A.N. (2000). Hair cell heterogeneity and ultrasonic hearing: recent advances in understanding fish hearing. *Philosophical Transactions of the Royal Society of Biological Sciences 29:*355:1277-80.

Popper, A.N. (2003). Effects of anthropogenic sound on fishes. *Fisheries* 28:24-31.

Popper, A.N. & B. Hoxter. (1984). Growth of a fish ear: 1. Quantitative analysis of sensory hair cell and ganglion cell proliferation. *Hearing Research* 15:133 142.

Popper, A.N. & B. Hoxter. (1987). Sensory and nonsensory ciliated cells in the ear of the sea lamprey, Petromyzon marinus. *Brain, Behavior and Evolution* 30:43-61.

Popper, A.N. & C. Platt. (1993). Inner ear and lateral line. pp. 99-136 In: *The Physiology of Fishes,* First Edition, edited by Evans DH. Boca Raton, FL: CRC Press, Inc., 1993.

Popper, A.N. & R.R. Fay. (1977). Structure and function of the elasmobranch auditory system. *American Zoologist,* 17:443-452.

Popper A.N., R.R. Fay, C. Platt, & O. Sand. (2003). Sound detection mechanisms and capabilities of teleost fishes. pp.3-38. In: *Sensory Processing in Aquatic Environments,* eds. S.P. Collin and N.J. Marshall, New York: Springer-Verlag.

Popper, A.N. & T.J. Carlson. (1998). Application of sound and other stimuli to control fish behavior. *Transactions of the American Fisheries Society* 127(5):673-707.

Popper, A.N. & W.N. Tavolga. (1981). Structure and function of the ear in the marine catfish, *Arius felis*. *Journal of Comparative Physiology* 144: 27-34.

Popper, A.N. & Z. Lu. (2000). Structure-function relationships in fish otolith organs. *Fisheries Research* 46: 15-25.

Popper, A.N., J. Fewtrell, M.E. Smith, & R.D. McCauley. (2004). Anthropogenic sound: Effects on the behavior and physiology of fishes. *Marine Technology Society Journal* 37(4): 35-40.

Popper, A.N., M.B. Halvorsen, E. Kane, D.D. Miller, M.E. Smith, P. Stein, & L.E. Wysocki. (2007). The effects of high-intensity, low-frequency active sonar on rainbow trout. *Journal of the Acoustical Society of America* 122:623-635.

Popper, A.N., M.E. Smith, P.A. Cott, B.W. Hanna, A.O. MacGillivray, M.E. Austin, & D.A. Mann. (2005). Effects of exposure to seismic airgun use on hearing of three fish species. *Journal of the Acoustical Society of America* 117(6): 3958-3971.

Poupin, J. (1996). Crustacea decapoda of French Polynesia (Astacidea, Palinuridea, Anomura, Brachyura). *Atoll Research Bulletin* 442:1-114.

Ramcharitar, J.U., D.M. Higgs, & Popper. (2001). Sciaenid inner ears: A study in diversity. *Brain, Behavior and Evolution* 58:152-162.

Ramcharitar, J.U. & A.N. Popper, A.N. (2004). Masked auditory thresholds of sciaenid fishes: a comparative study. *Journal of the Acoustical Society of America* 116:1687-1691.

Ramcharitar, J.U., D.M. Higgs, & A.N. Popper. (2006a). Audition in sciaenid fishes with different swim bladder-inner ear configurations. *Journal of the Acoustical Society of America* 119:439-443.

Ramcharitar, J.U., D. Gannon, & A.N. Popper. (2006b). Bioacoustics of fishes of the Family Sciaenidae (croakers and drums). *Transactions of the American Fisheries Society* 135:1409–1431.

Ramcharitar, J.U., X. Deng, D. Ketten, & A.N. Popper. (2004). Form and function in the unique inner ear of a teleost fish: The silver perch (*Bairdiella chrysoura*). *Journal of Comparative Neurolology* 475:531-539.

Randall, R.H. (1995). Biogeography of the reef-building corals in the Mariana and Palau Islands in relation to back-arc rifting and the formation of the Eastern Philippine Sea. *Natural History Research* 3(2):193-210.

Remage-Healey, L. & A.H. Bass. (2006). From social behavior to neural circuitry: steroid hormones rapidly modulate advertisement calling via a vocal pattern generator. *Hormones Behavior* 50:432-441.

Research Planning Inc. (1994). *Sensitivity of coastal environments and wildlife to spilled oil, Mariana Islands, Volume 1, Guam: A coastal atlas*. Columbia, South Carolina: Hazardous Materials Response and Assessment Division: National Oceanic and Atmospheric Administration.

Richardson, W.J., C.R. Greene, Jr., C.I. Malme, & D.H. Thompson. (1995a). *Marine mammals and noise*. Funded by Minerals Management Service: Office of Naval Research, LGL, Ltd., Greeneride Sciences, Inc., and BBN Systems and Technologies under MMS Contract 14-12-0001-30673. San Diego: Academic Press, Inc.

Richmond, R.H. & G.W. Davis. (2002). Status of the coral reefs of Guam. Pages 189-194 in D.D. Turgeon, R.G. Asch, B.D. Causey, R.E. Dodge, W. Jaap, K. Banks, J. Delaney, B.D. Keller, R. Speiler, C.A. Matos, J.R. Garcia, E. Diaz, D. Catanzaro, C.S. Rogers, Z. Hillis-Starr, R. Nemeth, M. Taylor, G.P. Schmahl, M.W. Miller, D.A. Gulko, J.E. Maragos, A.M. Friedlander, C.L. Hunter, R.S. Brainard, P. Craig, R.H. Richmond, G. Davis, J. Starmer, M. Trianni, P. Houk, C.E. Birkeland, A. Edward, Y. Golbuu, J. Gutierrez, N. Idechong, G. Paulay, A. Tafileichig, & N. Vander Velde. *The state of coral reef ecosystems of the United States and Pacific Freely Associated States: 2002*. Silver Spring, Maryland: National Oceanic and Atmospheric Administration/National Ocean Service/National Centers for Coastal Ocean Science.

Rogers P.H. & M. Cox. (1988). Underwater sound as a biological stimulus. pp. 131-149. In: *Sensory Biology of Aquatic Animals*, eds. A. Atema, R.R. Fay, A.N. Popper, & W.N. Tavolga, New York: Springer-Verlag.

Ross, Q.E., D.J. Dunning, J.K. Menezes, M.J. Kenna Jr., & G. Tiller. (1996). Reducing impingement of alewives with high-frequency sound at a power plant intake on Lake Ontario. *North American Journal of Fisheries Management* 16: 548-559.

Sadovy, Y., M. Kulbicki, P. Labrosse, Y. Letourneur, P. Lokani, & T.J. Donaldson. (2003). The humphead wrasse, *Cheilinus undulatus*: Synopsis of a threatened and poorly known giant coral reef fish. *Reviews in Fish Biology and Fisheries* 13:327-364.

Safina, C. (1996). *Xiphias gladius*. In: *IUCN 2004*. 2003 IUCN Red List of Threatened Species Retrieved November 16, 2004 from http://www.redlist.org

Sand ,O. & Karlsen H.E. (1986). Detection of infrasound by the Atlantic cod. *Journal of Experimental Biology* 125:197-204.

Sand, O., Enger P.S., Karlsen H.E., Knudsen F.R., & Kvernstuen T. (2000). Avoidance responses to infrasound in downstream migrating European silver eels, *Anguilla Anguilla*. *Environmental Biology of Fishes* 47:327-336.

Scholik, A.R. & H.Y. Yan. (2001). Effects of underwater noise on auditory sensitivity of a cyprinidfish. *Hearing Research* 152:1-2:17-24.

Scholik, A.R. & H.Y. Yan. (2002). The effects of noise on the auditory sensitivity of the bluegill sunfish, *Leptomis macrochirus*. *Comparative Biochemistry. Physiology, A Molecular Integration and Physiology* 133: 43-52. 34. Schwartz and Greer (1984).

Sevaldsen, E.M. & Kvadsheim, P.H. (2004). *Active sonar and the marine environment*. Norwegian Defense Research Establishment, Horten, Norway retrieved from http://www.mil.no/multimedia/archive/00052/_Active_sonar_and_th_52526a.pdf, 8 pp

Sisneros J.A. (2007). Saccular potentials of the vocal plainfin midshipman fish, *Porichthys notatus. Journal of Comparative Physiology A* 193:413-424.

Sisneros. J.A. & A.H. Bass. (2003). Seasonal plasticity of peripheral auditory frequency sensitivity. *Journal of Neuroscience* 23(3): 1049-1058.

Skalski, J.R., W.H. Pearson, & C.I. Malme. (1992). Effects of sounds from a geophysical survey device on catch-per-unit-effort in a hook-and-line fishery for rockfish (*Sebastes* spp). *Canadian Journal of Fisheries and Aquatic Science* 49:1357-1365.

Slotte, A., K. Kansen, J. Dalen, E., & Ona. (2004). Acoustic mapping of pelagic fish distribution and abundance in relation to a seismic shooting area off the Norwegian west coast. *Fisheries Research* 67:143-150.

Smale, M.J. (2000a). *Carcharhinus longimanus*. In: *IUCN 2004*. 2004 IUCN red list of threatened species Retrieved November 16, 2004 from http://www.redlist.org

Smale, M.J. (2000b). *Carcharhinus amblyrhynchos*. In: *IUCN 2004*. 2004 IUCN red list of threatened species retrieved November 23, 2004 from http://www.redlist.org

Smith, M.E., A.S. Kane, & A.N. Popper. (2004a). Noise-induced stress response and hearing loss in goldfish (*Carassius auritus*). *Journal of Experimental Biology 207:3591 602.*

Smith, M.E., A.S. Kane, & A.N. Popper. (2004b). Acoustical stress and hearing sensitivity in fishes: does the linear threshold shift hypothesis hold water? *Journal of Experimental Biology* 207:3591-602.

Smith, M.K. (1993). An ecological perspective on inshore fisheries in the main Hawaiian Islands. *Marine Fisheries Review* 55(2):34-49.

Smith, S.H., K.J.P. Deslarzes, & R. Brock. (2006). *Characterization of Fish and Benthic Communities of Pearl Harbor and Pearl Harbor Entrance Channel, Hawaii. Final Report- December 2006.* Contract Number: N62470-02-D-997; Task Order Number: 0069. (Funded by: Department of Defense Legal Resource Management Program, Project Number 03-183 – Naval Facilities Engineering Command).

Song, J., A. Mathieu, R.F. Soper, & A.N. Popper. (2006). Structure of the inner ear of bluefin tuna *Thunnus thynnus. Journal of Fish Biology 68: 1767–1781.* (Song *et al*. in press).

Starmer, J., M.S. Trianni, & P. Houk. (2002). *Status of coral reefs in the Commonwealth of the Northern Mariana Islands*. Pages 195-204 in D.D. Turgeon, R.G. Asch, B.D. Causey, R.E. Dodge, W. Jaap, K. Banks, J. Delaney, B.D. Keller, R. Speiler, C.A. Matos, J.R. Garcia, E. Diaz, D. Catanzaro, C.S. Rogers, Z. Hillis-Starr, R. Nemeth, M. Taylor, G.P. Schmahl, M.W. Miller, D.A. Gulko, J.E. Maragos, A.M. Friedlander, C.L. Hunter, R.S. Brainard, P. Craig, R.H. Richmond, G. Davis, J. Starmer, M. Trianni, P. Houk, C.E. Birkeland, A. Edward, Y. Golbuu, J. Gutierrez, N.

Stevens, J. (2000a). *Isurus oxyrinchus*. In: *IUCN 2004*. 2004 IUCN red list of threatened species Retrieved November 16, 2004 from http://www.redlist.org

Stevens, J. (2000b). *Prionace glauca*. In: *IUCN 2004*. 2004 IUCN red list of threatened species Retrieved November 16, 2004 from http://www.redlist.org

Sverdrup, A., E. Kjellsby, P.G. Krueger, R. Floysand, F.R. Knudsen, P.S. Enger, G. Serck-Hanssen G, & K.B. Helle. (1994). Effects of experimental seismic shock on vasoactivity of arteries, integrity of the vascular endothelium and on primary stress hormones of the Atlantic salmon. *Journal of Fish Biology* 45:973-995.

Tavolga, W.N. & J. Wodinsky. (1963). Auditory capacities in fishes. Pure tone thresholds in nine species of marine teleosts. *Bulletin of the American Museum of Natural History* 126:179-239.

Tavolga, W.N. & J. Wodinsky. (1965). Auditory capacities in fishes: threshold variability in the blue-striped grunt *Haemulon sciurus*. *Animal Behavior* 13:301-311.

Tavolga, W.N. (1974a). Sensory parameters in communication among coral reef fishes. *Mount Sinai Journal of Medicine* 41(2):324-340.

Turnpenny, A.W.H., K.P. Thatcher, & J.R. Nedwell. (1994). *The effects on fish and other marine animals of high-level underwater sound.* (Report FRR 127/94 prepared by Fawley Aquatic Research Laboratories, Ltd., Southampton, UK).

Uozumi, Y. (1996a). *Thunnus alalunga*. In: *IUCN 2004*. 2004 IUCN red list of threatened species retrieved November 16, 2004 from http://www.redlist.org

Uozumi, Y. (1996b). *Thunnus obesus*. In: *IUCN 2004*. 2004 IUCN red list of threatened species retrieved November 16, 2004 from http://www.redlist.org

U.S. Air Force. (1997) *Environmental Effects of Self-Protection Chaff and Flares*. Prepared for Headquarters Air Combat Command: Langley Air Force Base, Virginia.

U.S. Department of the Navy. (1999). *Final Environmental Impact Statement: Military Training in the Marianas*. Prepared for U.S. Pacific Command: Pearl Harbor, Hawaii by Belt Collins Hawaii, Honolulu, Hawaii.

Wardle, C.S., T.J. Carter, G.G. Urquhart, A.D.F. Johnstone, A.M. Ziolkowski, G. Hampson, & D. Mackie. (2001). Effects of seismic air guns on marine fish. *Continental Shelf Research* 21:1005-1027.

Webb, J.F., J. Montgomery, & J. Mogdans. (2008). Bioacoustics and the lateral line of fishes. In: *Fish Bioacoustics*, eds. J.F. Webb, R.R. Fay, & A.N. Popper. New York: Springer Science + Business Media, LLC.

Western Pacific Regional Fishery Management Council. (1998). *Magnuson-Stevens Act definitions and required revisions: Amendment 6 to the bottomfish and seamount groundfish fisheries management plan, Amendment 8 to the pelagic fisheries management plan, Amendment 10 to the crustacean fisheries management plan, and Amendment 4 to the precious corals fisheries management plan*. Honolulu, Hawaii: Western Pacific Regional Fishery Management Council, 449 pp.

Western Pacific Regional Fishery Management Council. (2001). *Final fishery management plan for coral reef ecosystems of the western Pacific region. Volumes I-III including Amendment 7 bottomfish and seamount groundfish fisheries, Amendment 11 crustacean fisheries, Amendment 5 precious corals fisheries, and Amendment 10 pelagic fisheries*. Honolulu, Hawaii: Western Pacific Regional Fishery Management Council.

Western Pacific Regional Fishery Management Council. (2004). *EFH/HAPC designations for fishery management units covered under the bottomfish, crustacean, pelagic, precious corals, and coral reef ecosystem fishery management plans.* Updated. Honolulu, Hawaii: WPRFMC. 7 pp.

Western Pacific Regional Fishery Management Council. (2005). *Draft Programmatic Environmental Impact Statement Towards an Ecosystem Approach for the Western Pacific Region: From Species-based Fishery Management Plans to Place-based Fishery Ecosystem Plans.* Retrieved October 28, from http://www.wpcouncil.org/documents/DPEIS.pdf

Westneat, M.W. (2001). Labridae - Wrasses (also hogfishes, razorfishes, corises, and tuskfishes). Pages 3381-3467 in K.E. Carpenter and V.H. Niem, eds. *FAO species identification guide for fishery purposes. The living marine resources of the western central Pacific. Volume 6: Bony fishes part 4 (Labridae to Latimeriidae), estuarine crocodiles, sea turtles, sea snakes and marine animals.* Rome, Italy: Food and Agriculture Organization of the United Nations.

Winn, H.E. (1967). Vocal facilitation and biological significance of toadfish sounds. pp. 283- 3036. In: *Marine Bio Acoustics, II*, ed. W.N. Tavolga, Oxford: Pergamon Press.

Wright, K.J., D.M. Higgs, A.J. Belanger, & J.M. Leis. (2005). Auditory and olfactory abilities of pre-settlement larvae and post-settlement juveniles of a coral reef damselfish (Pisces:Pomacentridae). *Marine Biology* 147: 1425-1434.

Wright, K.J., D.M. Higgs, A.J. Belanger, & J.M. Leis. (2007). Auditory and olfactory abilities of pre-settlement larvae and post-settlement juveniles of a coral reef damselfish (Pisces: Pomacentridae). Erratum. *Marine Biology* 150:1049-1050.

Wysocki, L.E. & F. Ladich. (2005). Hearing in fishes under noise conditions. *Journal of the Association of Research Otolaryngology* 6:28-36.

Wysocki, L.E., J.P. Dittami, & F. Ladich. (2006). Ship noise and cortisol secretion in European freshwater fishers. *Biological Conservation* 128:501-508.

Wysocki, L.E., J.W. III Davidson, M.E. Smith, A.S. Frankel, W.T. Ellison, P.M. Mazik, A.N. Popper, & J. Bebak. (2007). Effects of aquaculture production noise on hearing, growth, and disease resistance of rainbow trout *Oncorhynchus mykiss*. *Aquaculture* 272:687-697.

Yelverton, J.T. (1981). *Underwater explosion damage risk criteria for birds, fish and mammals*. (Paper presented at the 102nd of the Acoustical Society of America. Miami Beach, FL, pp. 19).

Yelverton, J.T., D.R. Richmond, W. Hicks, K. Saunders, & E.R. Fletcher. (1975). The Relationship Between Fish Size and Their Response to Underwater Blast. (Report DNA 3677 T, Director, Defense Nuclear Agency, Washington, DC).

Young, R.W. (1973). Sound pressure in water from a source in air and vice versa. *Journal of the Acoustical Society of America* 53:1708-1716.

Zelick, R., D. Mann, & Popper, A.N. (1999). Acoustic communication in fishes and frogs. pp. 363-411. In: *Comparative Hearing: Fish and Amphibians*, eds. R.R. Fay and A.N. Popper, New York: Springer-Verlag.

Section 3.10 References: Seabirds and Shorebirds

Acoustical Society of America. (1978). *Birds and Hearing Range*. Retrieved July 11, 2008 from http://www.newton.dep.anl.gov/askasci/zoo00/zoo00851.htm

Arfsten, D.P., C.L. Wilson, & B.J. Spargo. (2002). Review – Radio Frequency Chaff: The Effects of Its Use in Training on the Environment. *Ecotoxicology and Environmental* Safety 53:1-11.

Azzarello, M.Y. & E.S. Van Vleet. Marine Birds and Plastic Pollution. *Marine Ecology – Progress Series* 37:295-303.

Balance, L. T., R. L. Pitman, & S. B. Reilly. (1997). Seabird community structure along a productivity gradient: Importance of competion and energetic constraint. *Ecology* 78: 1502-1518.

BirdLife International. (2007). Online information for the Hawaiian Petrel. *BirdLife International, 2007*. Retrieved March 3, 2008 from http://www.birdlife.org/datazone/species/index.html?action=SpcHTMDetails.asp&sid=3896&m=0

Birdweb. (2005). Online information for the Parasitic Jaeger. *Seattle Audubobon Society*, updated 2005. Retrieved March 3, 2008 from http://birdweb.org/birdweb/bird_details.aspx?value=search&id=189

Black, A. (2005). Light Induced Seabird Mortality on Vessels Operating in the Southern Ocean: Incidents and Mitigation Measures. *Antarctic Science* 17:67-68.

Borberg, J.M., L.T. Balance, R.L. Pitman, & D.G. Ainley. (2005). A Test for Bias Attributable to Seabird Avoidance of Ships During Surveys Conducted in the Tropical Pacific. *Marine Ornithology* 33:173-179.

Bowles, A., Tabachnick, B., & Fidell, S. (1991). Review of the effects of aircraft overflights on wildlife (7500): *National Park Service*.

Brooke, A. (2007). Personal Communication via email. Anne Brooke, Ph.D., Department of the Navy Biologist, Guam Naval Annex and Taylor Houston, Parsons. August.

Bruderer, B., D. Peter, & T. Steuri. (1999). Behaviour of Migrating Birds Exposed to X-Band Radar and a Bright Light Beam. *The Journal of Experimental Biology* 202:1015-1022.

Camp, R. (2008). Unpublished report, as cited in letter to Navy from USFWS dated May 2, 2008.

Friesen *et al*. (2000). Friesen, V. L.; Anderson, D. J.; Steeves, T. E.; Jones, H. & Schreiber, E. A. (2002): *Molecular Support for Species Status of the Nazca Booby* (*Sula granti*). Auk 119(3): 820–826. [English with Spanish abstract]

Hamilton, W.J. (1958). Pelagic Birds Observed on a North Pacific Crossing. *The Condor* 60(3):159-164.

Harrison C. (1990). *Seabirds of Hawaii: natural history and conservation*. Cornell Univ. Press, Ithaca, NY.

Harrison, P. (1983). *Seabirds, an identification guide*. Houghton Mifflin Company, Boston.

Hullar, T. L., S. L. Fales, H. F. Hemond, P. Koutrakis, W. H. Schlesinger, R. R. Sobonya, J. M. Teal, & J. G. Watson. (1999). *Environmental Effects of Chaff: A Select Panel Report to the Undersecretary of Defense for Environmental Security*. (NRL/PU/6110-99-389). Naval Research Laboratory.

Hunter, W.C., W. Golder, S. Melvin, & J. Wheeler. (2006). *Southeast United States Regional Waterbird Conservation Plan*. North American Bird Conservation Initiative.

Hyrenbach, K.D. (2001). Albatross Response to Survey Vessels: Implications for Studies of the Distribution, Abundance, and Prey Consumption of Seabird Populations. *Marine Ecology Progress Series* 212:283-295.

Hyrenbach, K.D. (2006). *Training and Problem-Solving to Address Population Information Needs for Priority Species, Pelagic Species (Procellariiformes) and Other Birds at Sea*. Waterbird Monitoring Techniques Workshop: IV North American Ornithological Conference, Veracruz, Mexico, 2 and 3 October, 2006.

Larkin, R.P. (1996). *Effects of Military Noise on Wildlife: A Literature Review*. Center for Wildlife Ecology, Illinois natural History Survey prepared for U.S. Army Construction Engineering Research Laboratory, Champaign, Illinois.

Mann K. H. & Lazier J. N. (1996). *Dynamics of marine ecosystems*. Blackwell Science, Oxford.

McGowan, K. J. (2001). Introduction: The world of birds. *In Handbook of Bird Biology* (S. Podulka, R. Rohrbaugh, Jr., and R. Bonney, eds.) The Cornell Lab of Ornithology. Ithaca, New York.

Mora, C. & D. R. Robertson. (2005). Causes of latitudinal gradients in species richness: A test with fishes of the tropical eastern Pacific. *Ecology.* Vol. 86, No. 7, pp. 1771-1782.

Moser, M.L. & Lee, D.S. (1992). A fourteen-year survey of plastic ingestion by western North Atlantic seabirds. *Colonial Waterbirds* 15: 83–94.

Mostello, C. S.; Palaia, N. A. & Clapp, B. (2000). Gray-backed Tern (*Sterna lunata*). In: Poole, A. & Gill, F. (eds.): *The Birds of North America* 525. The Birds of North America, Inc., Philadelphia, PA.

National Park Service. (1994). *Report on Effects of Aircraft Overflights on the National Park System*. (Report to Congress prepared pursuant to Public Law 100-91, the national parks Overflights Act of 1987).

Naughton, M. B, M. D. Romano, & T. S. Zimmerman. (2007). *A Conservation Action Plan for Black-footed Albatross (Phoebastria nigripes) and Laysan Albatross (P. immutabilis).* Version 1.0.

Navy Safety Center. (2004). *2002 – 2004 BASH Hazard Data Summaries*. Bird/Animal Hazard Strike (BASH) Division. Retrieved February 15, 2008 from http://www.safetycenter.navy.mil/aviation/operations/bash/default.htm

Nybo, S. (1996). Effects of Dietary Aluminum on Chicks Gallus gallus domesticus with Different Dietary Intake of Calcium and Phosphorus. *Archives of Environmental Contamination and Toxicology* 31:177-183.

Oedekoven, C. S., Ainley, D. G., & Spear, L.B. (2001). Variable responses of seabirds to change in marine climate: California Climate, 1985–1994. *Marine Ecology Progress Service* 212: 265–281.

Pepi, V. (2008). Comments received on the MIRC PDEIS. Unpublished raw data.

Pierce, K.E., R.J. Harris, L.S. Larned, & M.A. Pokras. (2004). Obstruction and Starvation Associated with Plastic Ingestion in a Northern Gannet Morus bassanus and a Greater Shearwater Puffinus gravis. *Marine Ornithology* 32:187-189.

Plumpton, D. (2006). *Review of Studies Related to Aircraft Noise Disturbance of Waterfowl, a Technical Report in Support of the Supplemental Environmental Impact Statement for the Introduction of F/A-18 E/F (Super Hornet) Aircraft to the East Coast of the United States*. Ecology and Environment, Inc., San Francisco, CA: prepared for Naval Facilities Engineering Command, Norfolk, VA.

Pratt, H. D., P. L. Bruner, & D. G. Berrett. (1987). *A Field Guide to the Birds of Hawaii and the Tropical* Pacific. Princeton University Press. Princeton, New Jersey.

Saunders, J. & Dooling, R. J. (1974). Noise-induced threshold shift in the parakeet (*Melopsittacus undulatus*). *Proc. Nat. Acad. Sci. USA*, 71:1962-1965.Scheuhammer, A.M. 1987. The Chronic Toxicity of Aluminum, Cadmium, Mercury, and Lead in Birds: A Review. *Environmental Pollution* 46:263-295.

Scheuhammer, A.M. (1987). The Chronic Toxicity of Aluminum, Cadmium, Mercury, and Lead in Birds: A Review. *Environmental Pollution* 46:263-295. Series 212, 265-281.

Spargo, B. (2007). Personal communication between Dr. Barry Spargo, Naval Research Laboratory, and Mark Collins, Parsons, June 1, 2007.

Stinson, D. W., M.W. Ritter, & J.D. Reichel. (1991). The Mariana common moorhen: Decline of an island endemic. *The Condor*, Vol. 93, No. 1, pp. 38-43.

Temple, S.A. (2001). Individuals, populations, and communities: The ecology of birds. *In Handbook of Bird Biology* (S. Podulka, R. Rohrbaugh, Jr., and R. Bonney, eds.) The Cornell Lab of Ornithology: Ithaca, New York.

U.S. Air Force. (1997). *Environmental Effects of Self-Protection Chaff and Flares, Final Report*. Air Combat Command: Langley Air Force Base, VA.

U.S. Department of the Navy. (2001). *Integrated Natural Resources Management Plan: Navy Lands, Guam*. Commander, U.S. Naval Forces Marianas. November 2001.

U.S. Department of the Navy. (2003). *Integrated Natural Resources Management Plan: Farallon de Medinilla and Tinian Military Lease Areas, Commonwealth of the Northern Marianas Islands*. Prepared for Commander, U.S. Naval Forces Marianas, by Helber Hastert and Fee, Planners. November 2003.

U.S. Department of the Navy. (2007). *Marine Mammal and Sea Turtle Survey and Density Estimates for Guam and the Commonwealth of the Northern Mariana Islands.* Final Report. Contract No. N68711-02-D-8043 Task Order No. 0036. Prepared for Naval Facilities Engineering Command Pacific. Commander, U.S. Navy, Pacific Fleet. Prepared by SRS-Parsons Joint Venture, Geo-Marine, Inc. and Bio-Waves, Inc. August.

U.S. Department of the Navy. (2008a). *Micronesian Megapode (Megapodius laperouse laperouse) Surveys on Farallon de Medinilla, Commonwealth of the Northern Marianas Islands (Draft).* Prepared by Scott Vogt, Wildlife Biologist. NAVFACPAC: NAVFAC Pacific. Honolulu, Hawaii. April. Unpublished raw data.

U.S. Department of the Navy. (2008b). *Wildlife Surveys on Military Leased Lands, Tinian, Commonwealth of the Northern Marianas Islands: Fiscal Years 2007 – 2008 Annual Report for 61755NR410 (Draft).* Prepared by Scott Vogt, Wildlife Biologist. NAVFACPAC: NAVFAC Pacific. Honolulu, Hawaii. April. Unpublished raw data.

U.S. Department of the Navy. (2008c). *Micronesian Megapode (Megapodius laperouse laperouse) Surveys on Tinian, Commonwealth of the Northern Marianas Islands (Draft).* Prepared by Scott Vogt, Wildlife Biologist. NAVFACPAC: NAVFAC Pacific. Honolulu, Hawaii. April. Unpublished raw data.

U.S. Department of the Navy. (2008d). *Wildlife Surveys on Military Leased Lands, Farallon de Meinilla, Commonwealth of the Northern Marianas Islands: Fiscal Years 2007 – 2008 Annual Report for 61755NR410 (Draft).* Prepared by Scott Vogt, Wildlife Biologist. NAVFACPAC: NAVFAC Pacific. Honolulu, Hawaii. April. Unpublished raw data.

U.S. Fish and Wildlife Service. (1983). *Hawaiian Dark-Rumped Petrel and Newell's Manx Shearwater recovery plan*. Portland, Oregon.

U.S. Fish and Wildlife Service. (1984a). *Biological Opinion for Kennel Bear*. (Consultation Number 1-2-84-F-26). U.S. Fish and Wildlife Service: Honolulu Ecological Services Field Office. Honolulu, Hawaii.

U.S. Fish and Wildlife Service. (1984b). *Biological Opinion for Marine Corps Training on Tinian*. (Consultation Number 1-2-84-F-44). U.S. Fish and Wildlife Service: Honolulu Ecological Services Field Office. Honolulu, Hawaii.

U.S. Fish and Wildlife Service. (1997a). *Biological Opinion for FDM Training May 1997 and July 1997*. (Consultation Number 1-2-97-F-05). U.S. Fish and Wildlife Service: Honolulu Ecological Services Field Office. Honolulu, Hawaii.

U.S. Fish and Wildlife Service. (1997b). *Biological Opinion for FDM Training September 1997*. (Consultation Number 1-2-97-F-05). U.S. Fish and Wildlife Service: Honolulu Ecological Services Field Office. Honolulu, Hawaii.

U.S. Fish and Wildlife Service. (1997c). *Biological Opinion for FDM Training September 1997*. (Consultation Number 1-2-97-F-06). U.S. Fish and Wildlife Service: Honolulu Ecological Services Field Office. Honolulu, Hawaii.

U.S. Fish and Wildlife Service. (1998). *Biological Opinion for FDM Training January - February 1998*. (Consultation Number 1-2-98-F-02). U.S. Fish and Wildlife Service, Honolulu Ecological Services Field Office. Honolulu, Hawaii.

U.S. Fish and Wildlife Service. (1999). *Biological Opinion for Military Training in the Marianas*. (Consultation Number 1-2-98-F-07). U.S. Fish and Wildlife Service: Honolulu Ecological Services Field Office. Honolulu, Hawaii.

U.S. Fish and Wildlife Service. (2005a). *Regional Seabird Conservation Plan, Pacific Region*. U.S. Fish and Wildlife Service: Migratory Birds and Habitat Programs, Pacific Region, Portland, Oregon.

U.S. Fish and Wildlife Service. (2005b). *Short-tailed Albatross Draft Recovery Plan*. Anchorage, Alaska.

U.S. Fish and Wildlife Service. (2007). *Biological Opinion for Establishment and Operation of an Intelligence, Surveillance, Reconnaissance, and Strike Capability at Andersen Air Force Base, Guam*. (Consultation Number 1-2-2006-F-266). U.S. Fish and Wildlife Service: Honolulu Ecological Services Field Office, Honolulu, Hawaii.

U.S. Fish and Wildlife Service and National Marine Fisheries Service. (1998). *Endangered Species Consultation Handbook: Procedures for Conducting Consultation and Conference Activities Under Section 7 of the Endangered Species Act*.

U.S. Geological Survey. (2008). Pomarine jaeger *Stercorarius pomarinus* retrieved July 9, 2008 from http://www.mbr-pwrc.usgs.gov/id/framlst/i0360id.html

Van Tuinen, Marcel; Waterhouse, David & Dyke, Gareth J. (2004) Avian molecular systematics on the rebound: a fresh look at modern shorebird phylogenetic relationships. *Journal of Avian Biology* 35(3): 191-194.

Vogt, S. (2008). Personal Communication via email. Scott Vogt, Biologist, NAVFACMAR. April 2008.

Section 3.12 References: Land Use

Commonwealth of the Northern Mariana Islands v United States of America. (2002). No. CV 99-0028. Web Site. Retrieved May 6, 2008 from http://www.state.gov/documents/organization/57533.pdf

Department of Defense. (1999). *Final Environmental Impact Statement – Military Training in the Marianas*. Prepared for Department of Defense: U.S. Pacific Command. Belt Collins, Hawaii.

Legal Information Institute. (2008). Title 48, Chapter 15, §1705. Web Site. Retreived May 6, 2008 from http://www4.law.cornell.edu/uscode/48/usc_sec_48_00001705----000-.html

Ocean Commission. (2004). *An Ocean Blueprint for the 21st Century*.

Tinian. (1983). *Tinian Lease Agreement – Lease Agreement Made Pursuant to the Covenant to Establish a Commonwealth of the Northern Mariana Islands in Political Union with the United States of America*.

U.S. Department of the Navy. (1998). *Marianas Training Plan for DoD Facilities and Activities.*

U.S. Department of the Navy. (2000). *COMNAVMARIANAINST 3500.4, Marianas Training Handbook* Prepared for Commander in Chief: U.S. Pacific Command Representative, Guam and the Commonwealth of the Mariana Islands.

U.S. Department of the Navy. (2003). Environmental Assessment for MOUT Training at Andersen South, Guam. U.S. Marine Corps and Naval Facilities Engineering Command: Pacific Division.

U.S. Department of the Navy. (2004). *Integrated Natural Resources Management Plan – Farallon de Medinilla and Tinian Military Lease Areas*. Prepared for Commander: U.S. Naval Forces Marianas. Helbert Hastert & Fee, Planners.

U.S. Department of the Navy. (2005a). *Regional Integrated Cultural Resource Management Plan for COMNAVMARIANAS Lands, Mariana Islands, Volume 1: Guam*. Prepared for Commander, U.S. Naval Forces Marianas. International Archaeological Research Institute, Inc. Honolulu, Hawaii.

U.S. Department of the Navy. (2005b). *COMNAVMARIANASINST 3502.1, Standard Operating Procedures and Regulations for Restricted Area 7201 and Farallon de Medinilla (FDM) Laser Bombing Range.*

U.S. Department of the Navy. (2006a). *Draft Decision Point 1 Recomendations Report Range Condition Assessment Marianas Land-Based Operational Range Complex Guam and Commonwealth Northern Mariana Islands*. Prepared for NAVFAC Pacific. Prepared by ECC: Hawaii.

U.S. Department of the Navy. (2006b). *Mariana Islands Range Complex Management Plan (RCMP), Volume II, 100% Draft*. Prepared for Commander: U.S. Pacific Fleet. Pearl Harbor, HI. SRS-Parsons JV.

U.S. Department of the Navy. (2007). *Guam Military Build-up Program Presentation*. Mr. Joe Ludovici, Deputy Director Joint Guam Program Office.

U.S. Fish and Wildlife Service. (2007). Guam National Wildlife Refuge Planning Update 2 Web Site. Retrieved May 6, 2008 from http://www.fws.gov/pacific/planning/main/docs/HI-PI/Guam/Planning%20Update%202.pdf

U.S. Fish and Wildlife Service. (2008). Guam National Wildlife Refuge Web Site. Retrieved October 7, 2008 from http://www.fws.gov/refuges/profiles/index.cfm?id=12518

U.S. Air Force. (2003). *Final Integrated Cultural Resource Management Plan for Andersen Air Force Base, Guam, 2003 Update*. Prepared for Earth Tech Global Environmental and U.S. Air Force Center for Environmental Excellence and 36 CES/CEVN Andersen AFB, Guam. International Archaeological Research Institute, Inc.

U.S. Air Force. (2005). *General Plan, Andersen Air Force Base, Guam* Prepared for Commander, 36th Wing. Parsons Inc.

U.S. Air Force. (2006). *Environmental Assessment Beddown of Training and Support Initiatives at Northwest Field Andersen Air Force Base, Guam*. Prepared for Pacific Air Forces, Hickam AFB, HI.

Woolley, John T. & Gerhard Peters. (2008). *The American Presidency Project* [online]. Santa Barbara, CA: University of California (hosted), Gerhard Peters (database). Web Site. Retrieved May 6, 2008 from http://www.presidency.ucsb.edu/ws/?pid=23805

Wyle. (2008). Aircraft Noise Study for Andersen Air Force Base, Guam. Prepared for Earth Tech, Inc. August.

Section 3.13 References: Cultural Resources

April, Vic. (2006). Talagi Pictograph Cave. *Micronesian, Journal of the Humanities and Social Sciences* 5(1/2):53-69.

Belt Collins Guam Ltd. (2007). *Na' Nina' etnunen Linahyan Ni' Manmaloffan, Connecting the Community to the Past, A Comprehensive Historic Preservation Plan for Guam, 2007-2011.* Prepared by Belt Collins Guam, Ltd. under the oversight of the Guam State Historic Preservation Office, Guam Historic Resources Division, Guam Department of Parks and Recreation. Retrieved from http://historicguam.org/Historic%20Preservation%20Plan%20for%20Guam.pdf

Brooks, Donovan. (2001). New Readiness Center Finished for Guam Army National Guard. *Stars and Stripes*. Retrieved from www.stripes.com/01/jul01/ed071201d.html

Cabrera, Genevieve S. (2005). *Historic and Cultural Sites of the CNMI: The National Register Sites.* CNMI Division of Historic Preservation, Saipan, CNMI. Retrieved from http://www.cnmihpo.com/Documents/histcultsitescnmi.pdf

Carrell, Toni, Don Boyer, Richard Davis, Marjorie G. Driver, Kevin Foster, Daniel J. Lenihan, David T. Lotz, Fr. Thomas B. McGrath, James E. Miculka, & Tim Rock. (1991a). *Micronesia Submerged Cultural Resources Assessment*. With contributions by Rose S. N. Manibusan, Dennis Blackenbaker, William Cooper, Edward Wood, and Suzanne Hendricks. Prepared by the Submerged Cultural Resources Unit, Southwest Cultural Resources Center, Southwest Region, National Park Service, U.S. Department of the Interior. Southwest Cultural Resources Center Professional Papers No. 36. Santa Fe, New Mexico.

Carrell, Toni, Daniel J. Lenihan, David T. Lotz, & James E. Miculka. (1991b). Shipwrecks: The Archaeological Record. In *Micronesia Submerged Cultural Resources Assessment,* by Toni Carrell, Don Boyer, Richard Davis, Marjorie G. Driver, Kevin Foster, Daniel J. Lenihan, David T. Lotz, Fr. Thomas B. McGrath, James E. Miculka, and Tim Rock with contributions by Rose S. N. Manibusan, Dennis Blackenbaker, William Cooper, Edward Wood, & Suzanne Hendricks. Pp. 327-466. Prepared by the Submerged Cultural Resources Unit, Southwest Cultural Resources Center, Southwest Region, National Park Service, U.S. Department of the Interior. Southwest Cultural Resources Center Professional Papers No. 36. Santa Fe, New Mexico.

Carrell, Toni, Kevin Foster, Daniel J. Lenihan, David T. Lotz, & James E. Miculka. (1991c). Other Submerged Cultural Resources: The Archaeological Record. . In *Micronesia Submerged Cultural Resources Assessment,* by Toni Carrell, Don Boyer, Richard Davis, Marjorie G. Driver, Kevin Foster, Daniel J. Lenihan, David T. Lotz, Fr. Thomas B. McGrath, James E. Miculka, & Tim Rock with contributions by Rose S. N. Manibusan, Dennis Blackenbaker, William Cooper, Edward Wood, & Suzanne Hendricks. Pp. 497-548. Prepared by the Submerged Cultural Resources Unit, Southwest Cultural Resources Center, Southwest Region, National Park Service, U.S. Department of the Interior. Southwest Cultural Resources Center Professional Papers No. 36. Santa Fe, New Mexico.

Carson, Mike T. & H. David Tuggle. (2007). *2007 Work Plan for Archaeological Surveys and Cultural Resources Studies on Guam and the Commonwealth of the Northern Marianas Islands in Support of the Joint Guam Build-up Environmental Impact Statement*. Prepared for the Department of the Navy, Naval Facilities Engineering Command (NAVFAC), Pacific, Pearl Harbor, Hawai'i. Prepared by International Archaeological Research Institute, Inc., Honolulu, Hawai'I with TEC Inc. Joint Venture.

Commonwealth of the Northern Marianas Islands. (2008a). *Rota Listings for the National Register of Historic Places*. Retrieved fromwww.cmnihpo.com/historicplaces.html and www.cmnihpo.com/Documents/cmni_us_registerlisting.pdf

Commonwealth of the Northern Marianas Islands. (2008b). *Saipan Listings for the National Register of Historic Places*. Retrieved from www.cmnihpo.com/historicplaces.html

Commonwealth of the Northern Marianas Islands. (2008c). *Tinian Listings for the National Register of Historic Places*. Retreived from www.cmnihpo.com/historicplaces.html and www.cmnihpo.com/Documents/cmni_us_registerlisting.pdf

Department of Defense. (1999a*). Memorandum of Agreement Among the Commander In Chief, U.S. Pacific Command Representative Guam and the Commonwealth of the Northern Marianas Islands*. The Commander, 36th Air Base Wing Andersen Air Force Base, the Guam Historic Preservation Officer, and the Advisory Council on Historic Preservation Regarding Military Training in the Marianas.

Department of Defense. (1999b). *Programmatic Agreement Among the Commander In Chief, U.S. Pacific Command Representative Guam and the Commonwealth of the Northern Marianas Islands (USCINCPAC REP GUAM/CNMI), the Advisory Council on Historic Preservation, and the CNMI Historic Preservation Officer Regarding the Implementation of Military Training on*

Tinian. Appendix D in the Updated Cultural Resources Management Plan for the Tinian Military Lease Area (MLA) by M.J. Tomonari-Tuggle, H. David Tuggle, & David J. Welch. Prepared for the Commander, Navy Region Marianas, Department of the Navy, Naval Facilities Engineering Command, Pacific, Pearl Harbor, Hawai'i. Prepared by International Archaeological Research Institute, Inc., Honolulu, Hawai'i.

Donato, Agnes E. (2006). *Reserve Center Dedicated to Fallen Soldiers*. Saipan Tribune. Retrieved from www.saipantribune.com/newsstory.aspx?newsID+62519&cat=1

Global Security. (2008). *Farallon de Medinilla (FDM)*. Retrieved January 29, 2008 from www.globalsecurity.org/military/facility/farallon-de-medinilla.htm

Grant, Marcus, Mikel Travisano, Sherri Wenzlau, & Mara Durst. (2007). *Results of Cultural Resource Inventories for Establishment and Operation of An Intelligience, Surveillance, Reconnaissance, and Strike Capability and the Deployment of Red Horse Squadron, Andersen Air Force Base, Guam*. Prepared for the Department of the Air Force, Headquarters Pacific Air Forces/A7P and the Air Force Center for Environmental Excellence: Brooks Air Force Base, Texas. Prepared by Geo-Marine, Inc., Plano, Texas.

Guam Register of Historic Places. (2008). *Guam Register of Historic Places*. Guam Historic Resources Division: Department of Parks and Recreation. Retrieved from http://historicguam.org/register.htm. www.cmnihpo.com/Documents/cmni_us_registerlisting.pdf

Lotz, David. (1994). *World War II Remnants: Guam, Northern Mariana Islands, A Guide and History.* Making Tracks, Publisher.

Mason Architects, Inc. (2004). *Historic Building and Associated Landscape/Viewsheds Inventory and Evaluation for Andersen Air Force Base, Guam, 2004 Update*. Prepared for Andersen Air Force Base, Guam.

National Register Information System. (2008a). *Guam Listings for the National Register of Historic Places*. National Register of Historic Places: National Park Service, Department of the Interior. Retrieved from http://www.nr.nps.gov/iwisapi/explorer.dll

National Register Information System. (2008b). *Mariana Islands Listings for the National Register of Historic Places*. National Register of Historic Places: National Park Service, Department of the Interior. Retrieved from http://www.nr.nps.gov/iwisapi/explorer.dll

Rainbird, Paul. (2004). *The Archaeology of Micronesia*. Cambridge University Press, New York, New York.

Sommer, Brenda. (2004). *Guam's Outstanding Contractors: Dick Pacific Construction Co., Ltd. (Guam).* Retrieved from www.buildingindustryhawaii.com/deepfreeze/bi034/034f_guam_outstanding.asp

Tomonari-Tuggle, M.J. & H. David Tuggle. (2003). *Integrated Cultural Resources Management Plan for Andersen Air Force Base, Guam, 2003 Update*. Prepared for Earth Tech Global Environmental, Colton, California; the U.S. Air Force Center for Environmental Excellence: Brooks Air Force Base, Texas; and 36 CES/CEVN, Andersen AFB, Guam. Prepared by International Archaeological Research Institute, Inc., Honolulu, Hawai'i.

Tomonari-Tuggle, M.J., H. David Tuggle, & David J. Welch. (2003). *Updated Cultural Resources Management Plan for the Tinian Military Lease Area (MLA)*. Prepared for the Commander: Navy Region Marianas, Department of the Navy, Naval Facilities Engineering Command, Pacific, Pearl Harbor, Hawai'i. Prepared by International Archaeological Research Institute, Inc., Honolulu, Hawai'i.

U.S. Air Force. (2006a). *Final Environmental Impact Statement, Establishment and Operation of an Intelligence, Surveillance, Reconnaissance, and Strike Capability at Andersen Air Force Base, Guam*. Prepared by the United States Air Force, Headquarters, Pacific Air Forces, Hickam Air Force Base, Hawai'i.

U.S. Air Force, (2006b). *Memorandum of Agreement between the United States Air Force and the Guam State Historic Preservation Office Regarding the Northwest Field Beddown Initiatives at Andersen Air Force Base, Guam.*

U.S. Department of the Navy. (2005) *Regional Integrated Cultural Resources Management Plan for COMNAVREG Marianas Lands, Volume I: Guam*. Prepared for the Commander, Navy Region Marianas, Department of the Navy, Naval Facilities Engineering Command, Pacific, Pearl Harbor, Hawai'i. Prepared by International Archaeological Research Institute, Inc., Honolulu, Hawai'i.

U.S. Department of the Navy.(2007). Notice of Intent to Prepare an Environmental Impact Statement (EIS)/Overseas Environmental Impact Statement (OEIS) for the Relocation of U.S. Marine Corps Forces to Guam, Enhancement of Infrastructure and Logistic Capabilities, Improvement of Pier/Waterfront Infrastructure for Transient U.S. Navy Nuclear Aircraft Carrier (CVN) at Naval Base, Guam, and Placement of a U.S. Army Ballistic Missile Defense (BMD) Task Force in Guam. *Federal Register*. Volume 72, Number 44, March 7, 2007.

U.S. Department of the Navy. (2008). Record of Decision for Kilo Wharf Extension (MILCON P-502) at Apra Harbor Naval Complex, Guam, Mariana Islands. *Federal Register.* Volume 73, Number 6, January 9, 2008.

Welch, David J. (1997). *Preliminary Archaeological Reconnaissance and Assessment of Farallon De Medinilla, Mariana Islands*. Manuscript on file, U.S. Navy, Honolulu, Hawai'i.

Welch, David J., Judith R. McNeill, Amanda A. Morgan, & Sandra Lee Yee. (2005). *Cultural Resources Synthesis for COMNAVREG Marianas Lands, Guam*. Prepared for the Department of the Navy, Naval Facilities Engineering Command, Pacific, Pearl Harbor, Hawai'i. Prepared by International Archaeological Research Institute, Inc., Honolulu, Hawai'i.

Yee, S., D. J. Welch, & J. Allen. (2004). *Final Archaeological Overview Survey Report for Andersen Air Force Base, Guam.* Manuscript on file, office of the Guam Historic Preservation Officer.

Section 3.14 References: Transportation

Central Intelligence Agency. (2008). The World Factbook: Guam. Web Site. Retrieved May 5, 2008 from https://www.cia.gov/library/publications/the-world-factbook/geos/gq.html

Center for Naval Analysis. (2001). *Navy vs. Commercial Trip Traffic*. Unclassified version memorandum for the Director, Environmental Protection, Safety, and Occupational Health Division (N45). 18 April. CNA (Center for Naval Analysis). 2004. Estimating Navy and Non-Navy Vessel Traffic in Areas of Interest. Prepared by Jonathon D. Mintz and Ronald J. Filadelfo. July.

Center for Naval Analysis. (2006). *Vessel Traffic and Speed Along the U.S. Coasts and Around Hawaii*. Prepared by Jonathon D. Mintz and Crystal L. Parker. January.

Davison, B. (2007). How many divers are there: And why you should care. *Undercurrent*. Sausalito, California. May.

Diving Equipment and Marketing Association. (2006). *Profile of the most active divers in the U.S.: Lifestyle and demographic study.* Diver Acquisition Project—Phase I.

Federal Aviation Administration. (2006). *Order 7400.2F, Procedures for Handling Airspace Matters.* February 16.

Franko's Maps. (2008). [Map]. Retrieved February 7, 2008 from http://frankosmaps.com/index.html

Guam Economic Development and Commerce Authority. (2008). Web Site. Retrieved February 7, 2008 from http://www.investguam.com/index.php?pg=transportation

Guam Visitor's Bureau. (2008). Web Site. Retrieved February 7, 2008 from http://visitguam.org/dive/

Historical Temporal Shipping. (1978). Planning Systems Inc., McLean VA. 28 Jun.

Marianas Visitor's Authority. Date unknown. Web Site. Retrieved February 7, 2008 from http://www.mymarianas.com/html/display.cfm?sid=1009

National Oceanic and Atmospheric Administration, Office of Coastal Survey. (2007). *Exclusive Economic Zone, for NOAA/National Ocean Service Nautical Charts, The Law of the Sea.* Web Site. Retrieved October 30, 2007 from http://chartmarker.ncd.noaa.gov/csdl/eez.htm

Research and Innovative Technology Administration's Bureau of Transportation Statistics. (2007). *National Transportation Atlas Databases* .

United Nations. (1982). *United National Convention on the Law of the Sea – Part V.*

U.S. Coast Guard. (2003). *2002 National Recreational Boating Survey State Data Report.*

U.S. Coast Guard. (2005). *Boating Statistics—2005. COMDTPUB P16754.19*.

U.S. Department of the Navy. (1999). *Final Environmental Impact Statement – Military Training in the Marianas.* Prepared by Belt Collins, Hawaii. June.

U.S. Department of the Navy. (2007). *Mariana Islands Range Complex Management Plan (Final Draft).*

Western Pacific Regional Fishery Management Council. (2005). *Fishery Ecosystem Plan for the Pacific Remote Island Areas.*

Section 3.15 References: Demographics

Commonwealth of Northern Mariana Islands Department of Commerce. (2000). Central Statistics. Census Reports. Web Site. Retrieved January 11, 2008 from http://www.commerce.gov.mp

Guam Bureau of Statistics and Plans. (2000). *2000 Decennial Census*. Web Site. Retrieved January 11, 2008 from http://www.bsp.guam.gov

U.S. Census Bureau. (2000). *State and County QuickFacts*. Web Site. Retrieved July 2, 3, 11, & 17, 2007 from http://quickfacts.census.gov/qfd/index.html

U.S. Census Bureau. (2003). Statistical Abstract of the United States: 2003. Source: U.S. Dept. of Defense, *Selected Manpower Statistics*, annual. Web Site. Retrieved October 24, 2007 from http://www.census.gov/prod/2004pubs/03statab/defense.pdf

U.S. Department of Defense. (2005). *Worldwide Manpower Distribution by Geographical Area*.

U.S. Department of Defense. (2007). *Active Duty Military Personnel Strengths by Regional Area and by Country September 30, 2007*. Web Site. Retrieved February 4, 2008 from www.siadapp.dmdc.osd.mil/personnel/Military/Miltop.htm

Section 3.16 References: Regional Economy

Bank of Hawaii. (2003). *Guam Economic Report.* Web Site. Retrieved May 27, 2008 from www.eastwestcenter.org/fileadmin/stored/pdfs/OsmanGuamEconomicReport2003.pdf

Guam Economic Development and Commerce Authority. (2008). Web Site. Retrieved May 27, 2008 from www.investguam.com/index.php?pg+tourism

Marianas Visitors Authority. (2008). *The Northern Mariana Islands Activities*. Web Site. Retrieved February 15, 2008 from www.mymarianas.com/html/display.cfm?sid=1059

National Oceanic and Atmospheric Administration. (2006). NOAA Pacific Islands Fisheries Science Center WPACFIN Menu *Regional Landings*. Web Site. Retrieved February 12, 2008 from www.pifsc.noaa.gov/wpacfin/central/Pages/central_data.php

National Oceanic and Atmospheric Administration. (2007a). *NOAA Pacific Islands Fisheries Science Center Commonwealth of the Northern Mariana Islands 2005 Fishery Statistics*.

National Oceanic and Atmospheric Administration. (2007b). *NOAA Pacific Islands Fisheries Science Center. WPACFIN Menu Estimated Commercial Landings Graphs*. Web Site. Retrieved February 12, 2008 from www.pifsc.noaa.gov/wpacfin/cnmi/Pages/cnmi_data_1.php

National Oceanic and Atmospheric Administration. (2007c). *NOAA Pacific Islands Fisheries Science Center Guam 2005 Fishery Statistics.*

National Oceanic and Atmospheric Administration. (2008a). NOAA Pacific Islands Fisheries Science Center, WPACFIN Menu, *Bottom Fisheries*. Web Site. Retrieved February 15, 2008 from www.pifsc.noaa.gov/wpacfin/cnmi/Pages/cnmi_fish_2.php

National Oceanic and Atmospheric Administration. (2008b). *Office of Coast Survey, Exclusive Economic Zone*. Web Site. Retrieved February 15, 2008 from http://nauticalcharts.noaa.gov/csdl/eez.htm

Office of Insular Affairs. (2008). *Department of the Interior Statement of David B. Cohen before the Senate Committee on Energy and Natural Resources regarding the State of the Economies and Fiscal Affairs of the Territories of American Samoa, The Commonwealth of the Northern Mariana Island, Guam and the United States Virgin Islands*. 1 March 2006

Pacific Business Center Program. (2008). *Commonwealth of the Northern Marianas, Economic Environment.* Web Site. Retrieved February 15, 2008 from http://www.hawaii.edu/pbcp/services/servicearea/cnmi.htm

Pula, Nikolao. (2008). *Statement of Nikolao Pula, Acting Deputy Assistant Secretary of the Interior for Insular Affairs Before the Senate Committee on ENery and Natural Resources Regarding the Military Build-up in Guam. Washington DC, May 1, 2008*. Web Site. Retrieved May 27, 2008 from www.energy.senate.gov/public/_files/PulaTestimony050108.doc

United Nations. (1982). *United Nations Convention on the Law of the Sea of 10 December 1982*. Web Site. Retrieved February 15, 2008 from www.un.org/Depts/los/convention_agreements/convention_overview_convention.htm

U.S. Census Bureau. (2002). *American FactFinder, Selected Statistics By Economic Sector*. Web Site. Retrieved July 3, 11, & 20, 2007 from http://factfinder.census.gov/

Western Pacific Regional Fishery Management Council. (2005a). *Fishery Ecosystem Plan for the Pacific Remote Island Areas*. 1 December 2005.

Western Pacific Regional Fishery Management Council. (2005b). *About the Western Pacific Regional Fishery Management Council*. Web Site. Retrieved February 5, 2008 from www.wpcouncil.org

Western Pacific Regional Fishery Management Council. (2005c). *Fishery Ecosystem Plan for the Mariana Archipelago*. 1 December 2005.

Section 3.17 References: Recreation

Aquasmith. Date unknown. [Map]. *Dive Sites Map*. Web Site. Retrieved February 27, 2008 from http://www.aquasmith.com/dive/divesites.htm#

Coral Reef Initiative Program. (2008). *CNMI Coral Reef Initiative Program*. Web Site. Retrieved March 2, 2008 from www.cnmicoralreef.net/mooring/mooring.htm

Coastal Resources Management Office. (2008). *Coral Reef Friendly*.

Fun Dive Guam. (2008). *Fun Dive Guam Explore, Learn, Smile*. Web Site. Retrieved March 2, 2008 from www.fundiveguam.com

Guam-online.com. (2001a). Web Site. Retrieved May 1, 2008 from http://www.guam-online.com/

Guam Visitors Bureau. (2006). *Dive Guam's Top Spots, in the waters of Micronesia.* Web Site. Retrieved March 2, 2008 from www.visitguam.org/dive

Guam Visitors Bureau. (2007a). *Guam Visitor's Statistics Report*. Web Site. Retrieved May 1, 2008 from http://visitguam.org/dynamicdata/asset/December%202007%20Monthly%20Report.pdf

Guam Visitors Bureau. (2007b). *2007 Annual Report*. Web Site. Retrieved May 1, 2008 from http://visitguam.org/members/GVB_Annual_Report/ANNUAL%20REPORT%2007.pdf

Guam Visitors Bureau. (2008a). *Hotels*. Web Site. Retrieved May 1, 2008 from http://visitguam.org/accomodations/

Guam Visitors Bureau. (2008b). Web Site. Retrieved February 7, 2008 from http://visitguam.org/dive/

Micronesian Divers Association, Guam and Micronesia Pacific Scuba Diving. (2008). *Welcome to the finest Dive Facility on Guam!* Web Site. Retrieved March 2, 2008 from www.mdaguam.com

Marianas Visitors Authority. (2008a). *The Northern Mariana Islands Activities*. Web Site. Retrieved February 15, 2008 from www.mymarianas.com/html/display.cfm?sid=1059

Marianas Visitors Authority. (2008b). *The Northern Mariana Islands Dive*. Web Site. Retrieved March 2, 2008 from www.mymarianas.com/html/display.cfm?sid=1003

Marianas Visitors Authority. (2008c). April 11, 2008. Media Releases: *March Arrivals Fall*. Web Site. Retrieved May 1, 2008 from http://www.mymarianas.com/html/display.cfm?sid=1797

National Park Service. (2001). *Special Study North Field Historic District*. Web Site. Retrieved May 1, 2008 from http://www.nps.gov/pwrh/Tinian/tiniandr.htm

National Oceanic and Atmospheric Administration. (2008a). Date Unknown. *Island of Guam Chart 81048*. Web Site. Retrieved March 3, 2008 from http://nauticalcharts.noaa.gov/mcd/Raster/download.htm

National Oceanic and Atmospheric Administration. (2008b). Date Unknown. *Apra Harbor Chart 81054*. Web Site. Retrieved March 3, 2008 from http://nauticalcharts.noaa.gov/mcd/Raster/download.htm

Office of Insular Affairs. (2008). *Department of the Interior Statement of David B. Cohen before the Senate Committee on Energy and Natural Resources regarding the State of the Economies and Fiscal Affairs of the Territories of American Samoa, The Commonwealth of the Northern Mariana Island, Guam and the United States Virgin Islands. 1 March 2006.*

Pacific Business Center Program. (2008). *Commonwealth of the Northern Marianas, Economic Environment*. Web Site. Retrieved February 15, 2008 from http://www.hawaii.edu/pbcp/services/servicearea/cnmi.htm

State of the Island Address. (2008). *Governor Felix P. Camacho, April 14, 2008*. Web Site. Retrieved from http://www.doi.gov/oia/pdf/2008%20Guam%20State%20of%20the%20Island%20Address%20Gov%20Camacho.pdf

U.S. Air Force. (2003). *Integrated Natural Resources Management Plan for Andersen Air Force Base, Guam.*

U.S. Coast Guard. (2006). *2006 Boating Statistics. COMDTPUB P16754.20.*

U.S. Department of the Navy. (2001). *Integrated Natural Resources Management Plan for Navy Lands, Guam*. 2001. COMNAVMARIANAS, Guam.

U.S. Department of the Navy. (2004). *Integrated Natural Resources Management Plan for Farallon De Medinilla and Tinian Military Lease Areas*. Commander, U.S. Naval Forces Mariana.

U.S. Department of the Navy. (2005). *Marine Resources Assessment for the Marianas Operating Area*.

U.S. Geological Survey. *U.S. Geographic Names Information System (GNIS)*. Reston, Virginia. Web Site. Retrieved March 3, 2008 from http://geonames.usgs.gov

Western Pacific Regional Fishery Management Council. (2005). *Fishery Ecosystem Plan for the Mariana Archipelago*. 1 December 2005.

Section 3.18 References: Environmental Justice

There are no references in this section.

Section 3.19 References: Public Health and Safety

U.S. Department of Defense. (1981). *Directive 4540.1, Use of Airspace by U.S. Military Seas.*

U.S. Department of the Navy. (1981). *Use of Airspace by U.S. Military Aircraft and Firing Over the High Seas.*

U.S. Department of Navy. (1993). *U.S. Pacific Fleet Instruction 3120.8F.* Commander, Naval Surface Force, U.S. Pacific Fleet.

Chapter 4 References: Other Considerations

There are no references in this section.

Chapter 5 References: Mitigation Measures

There are no references in this section.

Chapter 6 References: Cumulative Effects

Andrew, R.K., B.M. Howe, & J.A. Mercer. (2002). Ocean ambient sound: Comparing the 1960s with the 1990s for a receiver off the California coast. *Journal of the Acoustic Society of America* 3:65-70.

Arveson, P.T. & D.J. Vendittis. (2006). Radiated noise characteristics of a modern cargo ship. *Journal of the Acoustic Society of America* 107:118-129.

Baird, R.W. (2002). False killer whale *Pseudorca crassidens*. Pages 411-412 in W.F. Perrin, B. Würsig, & J.G.M. Thewissen, eds. *Encyclopedia of marine mammals*. San Diego: Academic Press.

Bauer, G.B., M. Fuller, A. Perry, J.R. Dunn, & J. Zoeger. (1985). Magnetoreception and biomineralization of magnetite in cetaceans. In: J.L. Kirschvink, D.S. Jones and B.J. MacFadden, eds. *Magnetite Biomineralization and Magnetoreception in Organisms*. Plenum Press, New York. pp. 489-507.

Beale, C. M., & P. Monaghan. (2004). Human disturbance: people as predation-free predators? *Journal of Applied Ecology* 41:335-343.

Bjørge, A. (2002). How persistent are marine mammal habitats in an ocean of variability? Pages 63-91 in P.G.H. Evans and J.A. Raga, eds. *Marine mammals: Biology and conservation*. New York: Kluwer Academic/Plenum Publishers.

Borell, A. (1993). PCB and DDTs in blubber of cetaceans from the northeastern North Atlantic. *Marine Pollution Bulletin* 26:146-151.

Bowen, W.D., C.A. Beck, & D.A. Austin. (2002). Pinniped ecology. Pages 911-921 in W.F. Perrin, B. Würsig, & J.G.M. Thewissen, eds. *Encyclopedia of marine mammals*. San Diego: Academic Press.

Brabyn, M.W. & I.G. McLean. (1992). Oceanography and Coastal Topography of Herd-Stranding Sites for Whales in New Zealand. *Journal of Mammalogy* 73:469-476.

Campagna, C., V. Falabella, & M. Lewis. (2007). Entanglement of southern elephant seals in squid fishing gear. *Marine Mammal Science* 23:414-418.

Carretta, T. Price, D. Petersen, & R. Read. (2004). Estimates of marine mammal, sea turtle, and seabird mortality in the California drift gillnet fishery for swordfish and thresher shark, 1996-2002. *Marine Fisheries Review* 66:21-30.

Carson, Mike T. & H. David Tuggle. (2007). *Work Plan for Archaeological Surveys and Cultural Resources Studies on Guam and the Commonwealth of the Northern Marianas Islands in Support of the Joint Guam Build-up Environmental Impact Statement*. Prepared for the Department of the Navy, Naval Facilities Engineering Command (NAVFAC), Pacific, Pearl Harbor, Hawai'i. Prepared by International Archaeological Research Institute, Inc., Honolulu, Hawai'I with TEC Inc. Joint Venture.

Council on Environmental Quality. (1997). *Considering Cumulative Effects under the National Environmental Policy Act*. Council on Environmental Quality. Executive Office of the President, Washington, D.C.

Chambers, S. & R.N. James. (2005). *Sonar termination as a cause of mass cetacean strandings in Geographe Bay, south-western Australia*. Acoustics 2005, Acoustics in a Changing Environment. Proceedings of the Annual Conference of the Australian Acoustical Society, November 9 - 11, 2005, Busselton, Western Australia.

Cockcroft, V.G., G. Cliff, & G.J.B. Ross. (1989). Shark predation on Indian Ocean bottlenose dolphins *Tursiops truncatus* off Natal, South Africa. *South African Journal of Zoology* 24:305-310.

Conner, R.C. (2000). Group living in whales and dolphins. IN: J. Mann, R.C. Conner, P.L. Tyack, & H. Whitehead, eds. *Cetacean Societies: Field Studies of Dolphins and Whales*. University of Chicago Press, Chicago. pp. 199-218.

Constantine, R., I. Visser, D. Buurman, R. Buurman, & B. McFadden. (1998). Killer whale (*Orcinus orca*) predation on dusky dolphins (*Lagenorhynchus obscurus*) in Kaikoura, New Zealand. *Marine Mammal Science* 14:324-330.

Corkeron, P.J. & R.C. Connor. (1999). Why do baleen whales migrate? *Marine Mammal Science* 15:1228-1245.

Crocker, D.E., D.P. Costa, B.J. Le Boeuf, P.M. Webb, & D.S. Houser. (2006). Impacts of El Niño on the foraging behavior of female northern elephant seals. *Marine Ecology Progress Series* 309:1-10.

Culik, B.M. (2002). Review on Small Cetaceans: Distribution, Behaviour, Migration and Threats, United Nations Environment Programme, Convention on Migratory Species. *Marine Mammal Action Plan/Regional Seas Reports and Studies* No. 177: 343 pp.

Curry, B.E. (1999). *Stress in mammals: The potential influence of fishery-induced stress on dolphins in the eastern tropical Pacific Ocean*. (NOAA Technical Memorandum NOAA-TMNMFS-SWFSC-260: 1-121).

Dunn, J.L., J.D. Buck, & T.R. Robeck. (2001). Bacterial diseases of cetaceans and pinnipeds. IN: L.A. Dierauf and F.M.D. Gulland, eds. CRC *Handbook of Marine Mammal Medicine*. CRC Press, Boca Raton, FL.

Evans, P.G.H., Anderwald, P., & Baines, M.E. (2003). UK Cetacean Status Review. Final Report to English Nature & Countryside Council for Wales. *Sea Watch Foundation*, Oxford, UK. 150pp.

Fair, P.A. & P.R. Becker. (2000). Review of stress in marine mammals. *Journal of Aquatic Ecosystem Stress and Recover*y 7:335-354.

Fiedler, P.C. (2002). Ocean environment. Pages 824-830 in W.F. Perrin, B. Würsig, & J.G.M. Thewissen, eds. *Encyclopedia of marine mammals*. San Diego: Academic Press.

Finneran, J.J., C.E. Schlundt, D.A. Carder, J.A. Clark, J.A. Young, J.B. Gaspin, & S.H. Ridgway. (2000). Auditory and behavioral responses of bottlenose dolphins (*Tursiops truncatus*) and a beluga whale (*Delphinapterus leucas*) to impulsive sounds resembling distant signatures of underwater explosions. *Journal of the Acoustical Society of America* 108:417-431.

Finneran, J.J., D.A. Carder, & S.H. Ridgway. (2003). *Temporary threshold shift measurements in bottlenose dolphins Tursiops truncatus, belugas Delphinapterus leucas, and California sea lions Zalophus californianus*. Environmental Consequences of Underwater Sound (ECOUS) Symposium, San Antonio, TX, 12-16 May 2003.

Finneran, J.J., D.A. Carder, C.E. Schlundt & S.H. Ridgway. (2005). Temporary threshold shift in bottlenose dolphins (*Tursiops truncatus*) exposed to mid-frequency tones. *Journal of Acoustical Society of America* 118:2696-2705.

Frid, A. (2003). Dall's sheep responses to overflights by helicopter and fixed-wing aircraft. *Biological Conservation* 110:387-399.

Forcada, J. (2002). Distribution. Pages 327-333 in W.F. Perrin, B. Würsig, & J.G.M. Thewissen, eds. *Encyclopedia of marine mammals*. San Diego: Academic Press.

Gaskin, D.E. (1982). *The ecology of whales and dolphins*. Portsmouth, New Hampshire: Heinemann.

Geraci, J.R., J. Harwood, & V.J. Lounsbury. (1999). Marine Mammal Die-Offs – Causes, Investigations, and Issues. *Conservation and Management of Marine Mammals* (ed. J.R. Twiss Jr. and R.R. Reeves), pp 367-395.

Geraci, J.R. & V.J. Lounsbury. (2005). *Marine Mammals Ashore: A Field Guide for Strandings, Second Edition.* National Aquarium in Baltimore, Baltimore, MD.

Gill, J.A., K. Norris, & W.J. Sutherland. (2001). Why behavioral responses may not reflect the population consequences of human disturbance. *Biological Conservation* 97:265-268.

Guinet, C., L.G. Barrett-Lennard, & B. Loyer. (2000). Co-ordinated attack behavior and prey sharing by killer whales at Crozet Archipelago:strategies for feeding on negativelybuoyant prey. *Marine Mammal Science* 16:829-834.

Gulland, F.M.D. & A.J. Hall. (2005). The Role of Infectious Disease in Influencing Status and Trends. IN: J.E. Reynolds III, W.F. Perrin, R.R. Reeves, S. Montgomery, T.J. Ragen. *Marine Mammal Research*. John Hopkins University Press, Baltimore. pp. 47-61.

Gulland, F.M.D. & A.J. Hall. (2007). Is marine mammal health deteriorating? Trends in global reporting of marine mammal disease. *EcoHealth* 4:135-150.

Harwood, J. (2002). Mass Die-offs. IN: W.F. Perrin, B. Würsig and J.G.M. Thewissen. *Encyclopedia of Marine Mammals.* Academic Press, San Diego: pp. 724-726.

Hickie, B.E., P.S. Ross, R.W. MacDonald & J.K.B. Ford. (2007). Killer whales (*Orcinus orca*) face protracted health risks associated with lifetime exposure to PCBs. *Environmental Science and Technology* 41:6613-6619.

Hiruki, L.M., M.K. Schwartz, & P.L. Boveng. (1999). Hunting and social behaviour of leopard seals (*Hydrurga leptonyx*) at Seal Island, South Shetland Islands, Antarctica. *Journal of Zoology* 249:97-109.

International Council for the Exploration of the Sea. (2005). *Report for the Ad-hoc Group on Impacts of Sonar on Cetaceans and Fish CM 2006/ACE: 25 pp.*

Jasny, M., J. Reynolds, C. Horowitz, & A. Wetzler. (2005). Sounding the Depths II: The rising toll of sonar, shipping, and industrial ocean noise on marine life. *Natural Resources Defense Council* 84 pp.

Jensen, A.S. & G.K. Silber. (2004). *Large whale ship strike database*. (NOAA Technical Memorandum NMFS-OPR-25, January 2004).

Kenney, R.D., P.M. Payne, D.W. Heinemann, & H.E. Winn. (1996). Shifts in northeast shelf cetacean distributions relative to trends in Gulf of Maine/Georges Bank finfish abundance. Pages 169-196 in K. Sherman, N.A. Jaworski, & T.J. Smayda, eds. *The northeast shelf ecosystem: assessment, sustainability, and management*. Boston: Blackwell Science.

Kirshvink, J.L., A.E. Dizon, & J.A. Westphal. (1986). Evidence from strandings for geomagnetic sensitivity in cetaceans. *Journal of Experimental Biology* 120:1-24.

Klinowska, M. (1985). Cetacean stranding sites relate to geomagnetic topography. *Aquatic Mammals* 1:27-32.

Klinowska, M. (1986). Cetacean Live Stranding Dates Relate to Geomagnetic Disturbances. Aquatic Mammals. 11:109-119. Dudok van Heel, W.H. 1966. Navigation in Cetaceans. IN: K.S. Norris, eds. *Whales, Dolphins, and Porpoises*. University of California Press, Berkeley, CA. pp. 597-606.

Kolinski, S.P., D.M. Parker, L.I. Ilo, & J.K. Ruak. (2001). An assessment of the sea turtles and their marine and terrestrial habitats at Saipan, Commonwealth of the Northern Mariana Islands. *Micronesia* 34(1):55-72.

Laist, D.W., A.R. Knowlton, J.G. Mead, A.S. Collet & M. Podesta. (2001). Collisions between ships and whales. *Marine Mammal Science* 17:35–75.

Learmonth, J.A., C.D. MacLeod, M.B. Santos, G.J. Pierce, H.Q.P. Crick & R.A. Robinson. (2006). Potential effects of climate change on marine mammals. *Oceanography and Marine Biology*. 44:431-464.

McDonald, M.A., J.A Hildebrand, & S.M. Wiggins. (2006). Increases in deep ocean ambient noise in the Northeast Pacific west of San Nicolas Island, California. *Journal of the Acoustical Society of America* 120:711-718.

Maldini, D., L. Mazzuca & S. Atkinson. (2005). Odontocete Stranding Patterns in the Main Hawaiian Islands. 1937-2002: How Do They Compare with Live Animal Surveys? *Pacific Science* 59:55-67.

Mazzuca, L., S. Atkinson, B. Keating, & E. Nitta. (1999). Cetacean mass strandings in the Hawaiian Archipelago, 1957-1998. *Aquatic Mammals* 25:105-114.

McDonald, M. A., J. A. Hildebrand, S. M. Wiggins, D. Thiele, D. Glasgow, & S. E. Moore. (2005). Sei whale sounds recorded in the Antarctic. *Journal of the Acoustical Society of America* 118:3941-3945.

National Marine Fisheries Service & U.S. Fish and Wildlife Service. (1998a). Recovery plan for U.S. Pacific populations of the East Pacific green turtle (Chelonia mydas). Silver Spring, Maryland.

National Marine Fisheries Service & U.S. Fish and Wildlife Service. (1998b). *Recovery plan for U.S. Pacific populations of the green turtle (Chelonia mydas).* Silver Spring, Maryland.

National Marine Fisheries Service. (1998c). *Endangered Species Act - Section 7 Consultation: Use of the Farallon de Medinilla live fire range by the U.S. Navy and other services. Biological Opinion*.

National Marine Fisheries Service. (2005). Office of Protected Resources. *Assessment of Acoustic Exposures on Marine Mammals in Conjunction with U.S.S. SHOUP Active Sonar Transmissions in the Eastern Strait of Juan de Fuca and Haro Strait, Washington, 5 May 2003.*

National Marine Fisheries Service. (2007c). Retrieved January 30, 2007 from http://www.nmfs.noaa.gov/pr/health/

National Marine Fisheries Service. (2007g). Retrieved January 31, 2007 from http://www.afsc.noaa.gov/NMML/education/cetaceans/ cetaceastrand.htm

National Marine Fisheries Service. (2007k). *July 2004 Mass Stranding of Melon-Headed Whales in Hawai'i Fact Sheet for Final Report*. Retrieved February 16, 2007 from http://www.nmfs.noaa.gov /pr/pdfs/health/stranding_melonheadedwhales_july2004.pdf

National Marine Fisheries Service. (2008). *National Marine Fisheries Office of Protected Resources memorandum to Chief of Naval Operations Environmental Readiness, 19 Jan 08.*

National Research Council. (2003). Ocean noise and marine mammals. *The National Academic Press*. Washington D.C. 208 pp.

National Research Council. (2005). Marine Mammal Populations and Ocean Noise: Determining When Noise Causes Biologically Significant Effects. *The National Academic Press*. Washington D.C. 126 pp.

O'Hara, T.M. & C. Rice. (1996). Polychlorinated biphenyls. In: A. Fairbrother, L. Locke, & G Hoff (eds). *Noninfectious diseases of wildlife*, 2nd edition. Iowa State University Press, Ames, Iowa.

O'Shea, T.J. & R.L. Brownell. (1994). Organochlorine and metal contaminants in baleen whales: a review and evaluation of conservation implications. *Science of the Total Environment* 154:179-200.

Payne, P.M., J.R. Nicolas, L. O'Brien, & K.D. Powers. (1986). The distribution of the humpback whale, *Megaptera novaeangliae*, on Georges Bank and in the Gulf of Maine in relation to densities of the sand eel, *Ammodytes americanus*. *Fishery Bulletin* 84:271-277.

Perrin, W.F. & R.L. Brownell. (2002). Minke whales *Balaenoptera acutorostrata* and *B. bonaerensis.* Pages 750-754 in W.F. Perrin, B. Würsig, & J.G.M. Thewissen, eds. *Encyclopedia of marine mammals.* San Diego: Academic Press.

Perrin, W. F. & J. R. Geraci. (2002). Stranding. IN: W.F. Perrin, B. Würsig, & J.G.M. Thewissen, eds. *Encyclopedia of Marine Mammals*. San Diego, Academic Press: pp. 1192-1197.

Pitman, R. L., L. T. Ballance, S. L. Mesnick, & S. J. Chivers. (2001). Killer whale predation on sperm whales: Observations and implications. *Maine Mammal Science* 17, 494-507.

Polefka, S. (2004). *Anthropogenic Noise and the Channel Islands National Marine Sanctuary*. (eport by Environmental Defense Center, Santa Barbara, CA. 51 pp).

Pritchard, P.C.H. (1995). Marine turtles of Micronesia. Pages 263-274 in K.A. Bjorndal, ed. *Biology and conservation of sea turtles*. Rev. ed. Washington, D.C.: Smithsonian Institution Press.

Read, A.J., P. Drinker, & S. Northridge. (2006). Bycatch of Marine Mammals in U.S. and Global Fisheries. *Conservation Biology* 20:63-169.

Richardson, W.J., C.R. Greene, Jr., C.I. Malme, & D.H. Thompson. (1995). *Marine mammals and noise*. San Diego: Academic Press, Inc.

Robinson, S., L. Wynen, & S. Goldsworthy. (1999). Predation by a Hooker's sea lion (*Phocarctos hookeri*) on a small population of fur seals *Arctocephalus* spp.) at Macquarie Island. *Marine Mammal Science 15, 888-893.*

Romero, L. M. (2004). Physiological stress in ecology: lessons from biomedical research. *Trends in Ecology and Evolution* 19:249-255.

Selzer, L.A. & P.M. Payne. (1988). The distribution of white-sided dolphins (*Lagenorhynchus acutus*) and common dolphins. *Delphinus delphis*) vs. environmental features of the continental shelf of the northeastern United States. *Marine Mammal Science* 4:141-153

Soto, N.A., M. Johnson, P.T. Madsen, P.L. Tyack, A. Bocconcelli & J.F. Borsani. (2006). Does intense ship noise disrupt foraging in deep-diving Cuvier's beaked whales (*Ziphius cavirostris*)? *Marine Mammal Science* 22:690-699.

Southall, B. (2006). *Declaration of Brandon L. Southall, Ph.D. Natural Resources Defense Council v Donald C. Winter (RIMPAC), June 30, 2006.*

Stern, J.S. (1992). Surfacing rates and surfacing patterns of minke whales (*Balaenoptera acutorostrata*) off central California, and the probability of a whale surfacing within visual range. *Reports of the International Whaling Commission* 42:379-385.

Stevick, P.T., B.J. McConnell, & P.S. Hammond. (2002). Patterns of movement. Pages 185-216 in A.R. Hoelzel, ed. *Marine mammal biology: An evolutionary approach*. Oxford: Blackwell Science.

U.S. Department of the Navy. (2007). *Final Supplemental Overseas Environmental Impact Statement and Environmental Impact Statement for Surveillance Towed Array Sensor System Low Frequency Active (SURTASS LFA) Sonar.* Department of the Navy, Chief of Naval Operations.

U.S. Fish and Wildlife Service & National Marine Fisheries Service. (1998e). *Endangered Species Consultation Handbook, Procedures for Conducting Consultations and Conference Activities under Section 7 of the Endangered Species Act.*

Van Dolah, F.M. (2005). Effects of Harmful Algal Blooms. IN: J.E. Reynolds III, W.F. Perrin, R.R. Reeves, S. Montgomery, T.J. Ragen. *Marine Mammal Research*. John Hopkins University Press, Baltimore. pp. 85-99.

Visser, I.K.G., J.S. Teppema, & A.D.M.E. Ostrhaus. (1991). Virus infections of seals and other pinnipeds. *Reviews in Medical Microbiology*. 2:105-114.

Walker, M.M., J.L. Kirschvink, G. Ahmed, & A.E. Dicton. (1992). Evidence that fin whales respond to the geomagnetic field during migration. *Journal of Experimental Biology*. 171:67-78.

Walsh, M. T., R. Y. Ewing, D. K. Odell & G. D. Bossart. (2001). Mass Stranding of Cetaceans. *CRC Handbook of Marine Mammals*. L. A. Dierauf and F. M. D. Gulland, CRC Press: pp. 83-93.

Wartzok, D. & D.R. Ketten. (1999). Marine Mammal Sensory Systems. *Biology of Marine Mammals* ed. J.E. Reynolds III and S.A. Rommel, pp 324-422.

Weise, M.J., D.P. Costa, & R.M. Kudela. (2006). Movement and diving behavior of male California sea lion (*Zalophus californianus*) during anomalous oceanographic conditions of 2005. *Geophysical Research Letters* 33:L22S10.

Whitehead, H. (2003). *Sperm whales: Social evolution in the ocean*. Chicago: University of Chicago Press.

Zeeberg, J., A. Corten & E. de Graaf. (2006). Bycatch and release of pelagic megafauna in industrial trawler fisheries off Northwest Africa. *Fisheries Research* 78: 186-195.

This page intentionally left blank.

CHAPTER 8 GLOSSARY OF TERMS

Access—the right to transit to and from and to make use of an area.

Activity—an individual scheduled training function or action such as missile launching, bombardment, vehicle driving, or Field Carrier Landing Practice.

Aeronautical Chart—a map used in air navigation containing all or part of the following: topographic features, hazards and obstructions, navigation aids, navigation routes, designated airspace, and airports.

Aesthetic—a pleasing appearance, effect, or quality that allows appreciation of character-defining features, such as of the landscape.

Air Basin—a region within which the air quality is determined by the meteorology and emissions within it with minimal influence on and impact by contiguous regions.

Air Traffic Control Assigned Airspace (ATCAA)—an area of airspace of defined vertical and lateral limits assigned by FAA Air Traffic Control.

Air Route Traffic Control Center (ARTCC)—a facility established to provide air traffic control service to aircraft operating on Instrument Flight Rules flight plans within controlled airspace and principally during the en route phase of flight. When equipment capabilities and controller workload permit, certain advisory/assistance services may be provided to aircraft operating under Visual Flight Rules.

Air Traffic Control—a service operated by appropriate authority to promote the safe, orderly, and expeditious flow of air traffic.

Airfield—usually an active and/or inactive airfield, or infrequently used landing strip, with or without a hard surface, without Federal Aviation Administration-approved instrument approach procedures. An airfield has no control tower and is usually private.

Airport—usually an active airport with hard-surface runways of 3,000 feet or more, with Federal Aviation Administration approved instrument approach procedures regardless of runway length or composition. An airport may or may not have a control tower. Airports may be public or private.

Airspace, Controlled—airspace of defined dimensions within which air traffic control service is provided to Instrument Flight Rules flights and to Visual Flight Rules flights in accordance with the airspace classification. Controlled airspace is divided into five classes, dependent upon location, use, and degree of control: Class A, B, C, D, and E.

Airspace, Special Use—airspace of defined dimensions identified by an area on the surface of the earth wherein activities must be confined because of their nature and/or wherein limitations may be imposed upon non-participating aircraft.

Airspace, Uncontrolled—uncontrolled airspace, or Class G airspace, has no specific definition but generally refers to airspace not otherwise designated and operations below 1,200 feet above ground level. No air traffic control service to either Instrument Flight Rules or Visual Flight Rules aircraft is provided other than possible traffic advisories when the air traffic control workload permits and radio communications can be established.

Airspace—the space lying above the earth or above a certain land or water area (such as the Pacific Ocean); more specifically, the space lying above a nation and coming under its jurisdiction.

Airway—Class E airspace established in the form of a corridor, the centerline of which is defined by radio navigational aids.

Alert Area—a designated airspace in which flights are not restricted but there is concentrated student training or other unusual area activity of significance.

Alkaline—basic, having a pH greater than 7.

Alluvium—a general term for clay, silt, sand, gravel, or similar unconsolidated material deposited during comparatively recent geologic time by a stream or other body of running water as a sorted or semi-sorted sediment in the bed of the stream or on its floodplain or delta, or as a cone or fan at the base of a maintained slope.

Aluminum Oxide (Al_2O_3)—a common chemical component of missile exhaust. Under natural conditions, the chemical is not a source of toxic aluminum; the U.S. Environmental Protection Agency has determined that nonfibrous Al_2O_3, as found in solid rocket motor exhaust, is nontoxic.

Ambient Air Quality Standards—legal limitations on pollutant concentration levels allowed to occur in the ambient air established by the U.S. Environmental Protection Agency or state agencies. Primary ambient air quality standards are designed to protect public health with an adequate margin of safety. Secondary ambient air quality standards are designed to protect public welfare-related values including property, materials, and plant and animal life.

Ambient Air—that portion of the encompassing atmosphere, external to buildings, to which the general public has access.

Amplitude—the maximum departure of the value of a sound wave from the average value.

Anthropogenic—human-related.

Aquaculture—the cultivation of the natural produce of water, such as fish or shellfish.

Archaeology—a scientific approach to the study of human ecology, cultural history, prehistory and cultural processes, emphasizing systematic interpretation of material remains.

Area of Potential Effect—the geographic area within which direct and indirect impacts generated by the Proposed Action and alternatives could reasonably be expected to occur and thus cause a change in historic, architectural, archaeological, or cultural qualities possessed by the property.

Artifact—any thing or item that owes its shape, form, or placement to human activity. In archaeological studies, the term is applied to portable objects (e.g., tools and the by-products of their manufacture).

Attainment Area—an air quality control region that has been designated by the U.S. Environmental Protection Agency and the appropriate state air quality agency as having ambient air quality levels as good as or better than the standards set forth by the National Ambient Air Quality Standards, as defined in the Clean Air Act. A single geographic area may have acceptable levels of one criteria air pollutant, but unacceptable levels of another; thus, an area can be in attainment and non-attainment status simultaneously.

Average Daily Traffic (ADT)—the total volume of traffic passing a given point or segment of a roadway in both directions divided by a set number of days.

A-weighted Sound Level—a number representing the sound level which is frequency-weighted according to a prescribed frequency response established by the American National Standards Institute (ANS1.4-19711) and accounts for the response of the human ear.

Azimuth—a distance in angular degrees in a clockwise direction from the north point.

Benthic Communities—of or having to do with populations of bottom-dwelling flora or fauna of oceans, seas, or the deepest parts of a large body of water.

Benthopelagic—living and feeding near the sea floor as well as in midwaters or near the surface.

Benthos—the sea floor.

Bioaccumulation—building up of a substance, such as PCBs, in the systems of living organisms (and thus, a food web) due to ready solubility in living tissues.

Biological Diversity—the complexity and stability of an ecosystem, described in terms of species richness, species evenness, and the direct interaction between species such as competition and predation.

Biological Resources—a collective term for native or naturalized vegetation, wildlife, and the habitats in which they occur.

Booster—an auxiliary or initial propulsion system that travels with a missile or aircraft and that may not separate from the parent craft when its impulse has been delivered; may consist of one or more units.

Brackish—slightly salty; applicable to waters whose saline content is intermediate between that of streams and sea water.

Calcareous—containing calcium carbonate.

Candidate Species—a species of plant or animal for which there is sufficient information to indicate biological vulnerability and threat, and for which proposing to list as "threatened" or "endangered" is or may be appropriate.

Carbon Dioxide—a colorless, odorless, incombustible gas which is a product of respiration, combustion, fermentation, decomposition and other processes, and is always present in the atmosphere.

Carbon Monoxide—a colorless, odorless, poisonous gas produced by incomplete fossil-fuel combustion; it is one of the six pollutants for which there is a national ambient standard (see Criteria Pollutants).

Cetacean—an order of aquatic, mostly marine, animals including the whales, dolphins, porpoise, and related forms with large head, fishlike nearly hairless body, and paddle-shaped forelimbs.

Class A Airspace (also Positive Controlled Area)—airspace designated in Federal Aviation Administration Regulation Part 71 within which there is positive control of aircraft

Coastal Zone—a region beyond the littoral zone occupying the area near the coastline in depths of water less than 538.2 feet. The coastal zone typically extends from the high tide mark on the land to the gently sloping, relatively shallow edge of the continental shelf. The sharp increase in water depth at the edge of the continental shelf separates the coastal zone from the offshore zone. Although comprising less than 10 percent of the ocean's area, this zone contains 90 percent of all marine species and is the site of most large commercial marine fisheries. This may differ from the way the term "coastal zone" is defined in the State Coastal Zone Management Program.

Community—an ecological collection of different plant and animal populations within a given area or zone.

Component (Cultural Resources)—a location or element within a settlement or subsistence system. Archaeological sites may contain several components that reflect the use of the locality by different groups in different time periods.

Continental Shelf—a shallow submarine plain of varying width forming a border to a continent and typically ending in a steep slope to the oceanic abyss.

Continental Slope—the steep slope that starts at the shelf break about 492 to 656 feet and extends down to the continental rise of the deep ocean floor.

Continental United States (CONUS)—the United States and its territorial waters between Mexico and Canada, but excluding overseas states.

Controlled Access—area where public access is prohibited or limited due to periodic training operations or sensitive natural or cultural resources.

Controlled Airspace—airspace of defined dimensions within which air traffic control service is provided to Instrument Flight Rules flights and to Visual Flight Rules flights in accordance with the airspace classification. Controlled airspace is divided into five classes, dependent upon location, use, and degree of control: Class A, B, C, D, and E.

Controlled Firing Area (CFA)—airspace wherein activities are conducted under conditions so controlled as to eliminate hazards to non-participating aircraft and to ensure the safety of persons and property on the ground.

Copepod—a small, shrimp-like crustacean.

Coral Reef—a calcareous organic area composed of solid coral and coral sand.

Council on Environmental Quality (CEQ)—established by the National Environmental Policy Act, the CEQ consists of three members appointed by the President. A CEQ regulation (Title 40 Code of Federal Regulations 1500-1508, as of July 1, 1986) describes the process for implementing the National Environmental Policy Act, including preparation of environmental assessments and environmental impact statements, and the timing and extent of public participation.

Co-Use—Scheduled uses that safely allow other units to transit the area or conduct activities.

Criteria Pollutants—pollutants identified by the U.S. Environmental Protection Agency (required by the Clean Air Act to set air quality standards for common and widespread pollutants); also established under state ambient air quality standards. There are standards in effect for six criteria pollutants: sulfur dioxide, carbon monoxide, particulate matter, nitrogen dioxide, ozone, and lead.

Cultural Resources—prehistoric and/or historic sites, structures, districts, artifacts, or any other physical evidence of human activity considered of importance to a culture, subculture, or community for scientific, traditional, religious, or any other reason.

Culture—a group of people who share standards of behavior and have common ways of interpreting the circumstances of their lives.

Cumulative Impact—the impact of the environment which results from the incremental impact of the action when added to the other past, present, and reasonably foreseeable future actions regardless of what agency (federal or non-federal) or person undertakes such other actions. Cumulative impacts can result from individually minor but collectively significant actions taking place over a period of time.

Current—a horizontal movement of water or air.

C-weighted—utilized to determine effects of high-intensity impulsive sound on human populations, a scale providing unweighted sound levels over a frequency range of maximum human sensitivity.

Danger Area—(1) In air traffic control, an airspace of defined dimensions within which activities dangerous to the flight of aircraft may exist at specified times; (2) (DoD only) A specified area above, below, or within which there may be potential danger.

Decibel (dB)—the accepted standard unit of measure for sound pressure levels. Due to the extremely large range of measurable sound pressures, decibels are expressed in a logarithmic scale.

Degradation—the process by which a system will no longer deliver acceptable performance.

Demersal—living close to the seafloor.

Direct Effects—immediate consequences of program activities.

Direct Impact—effects resulting solely from program implementation.

District—National Register of Historic Places designation of a geographically defined area (urban or rural) possessing a significant concentration, linkage, or continuity of sites, structures, or objects united by past events (theme) or aesthetically by plan of physical development.

Diurnal—active during the daytime.

Dunes—hills and ridges of sand-size particles (derived predominantly from coral and seashells) drifted and piled by the wind. These dunes are actively shifting or are so recently fixed or stabilized that no soil horizons develop; their surface typically consists of loose sand.

Ecosystem—all the living organisms in a given environment with the associated non-living factors.

Effects—a change in an attribute, which can be caused by a variety of events, including those that result from program attributes acting on the resource attribute (direct effect); those that do not result directly from the action or from the attributes of other resources acting on the attribute being studied (indirect effect); those that result from attributes of other programs or other attributes that change because of other programs (cumulative effects); and those that result from natural causes (for example, seasonal change).

Effluent—an outflowing branch of a main stream or lake; waste material (such as smoke, liquid industrial refuse, or sewage) discharged into the environment.

Electromagnetic Radiation (EMR)—waves of energy with both electric and magnetic components at right angles to one another.

Electronic Countermeasures (ECM)—includes both active jamming and passive techniques. Active jamming includes noise jamming to suppress hostile radars and radios, and deception jamming, intended to mislead enemy radars. Passive ECM includes the use of chaff to mask targets with multiple false echoes, as well as the reduction of radar signatures through the use of radar-absorbent materials and other stealth technologies.

En Route Airways—a low-altitude (up to, but not including 18,000 feet [5,486.4 meters] mean sea level) airway based on a center line that extends from one navigational aid or intersection to another navigational aid (or through several navigational aids and intersections) specified for that airway.

En Route Jet Routes—high altitude (above 18,000 feet mean sea level) airway based on a center line that extends from one navigational aid or intersection to another navigational aid (or through several navigational aids and intersections) specified for that airway.

Encroachment—the placement of an unauthorized structure or facility on someone's property or the unauthorized use of property.

Endangered Species—a plant or animal species that is threatened with extinction throughout all or a significant portion of its range.

Endemic—plants or animals that are native to an area or limited to a certain region.

Environmental Justice—an identification of potential disproportionately high and adverse impacts on low-income and/or minority populations that may result from proposed Federal actions (required by Executive Order 12898).

Epibenthic—living on the ocean floor.

Epipelagic—living in the ocean zone from the surface to 109 fathoms (656 feet).

Erosion—the wearing away of a land surface by water, wind, ice, or other geologic agents.

Estuary—a water passage where the tide meets a river current; an arm of the sea at the lower end of a river; characterized by brackish water.

Event—a significant operational employment during which training is accomplished. "Event" is a Navy approved employment schedule term. The event may be primarily designated as operational, such as TRANSIT, MIO, or STRIKEOPS during which training may take place. Training events may be periods of operational employment that are also considered major training events such as Composite Training Unit Exercise (COMPTUEX), Joint Training Fleet Exercise (JTFEX), or other exercises such as BRIGHT STAR, COBRA GOLD, or UNIFIED **Exclusive Use**—scheduled solely for the assigned unit for safety reasons.

Exotic—not native to an area.

Explosive Ordnance Disposal (EOD)—the process of recovering and neutralizing domestic and foreign conventional, nuclear and chemical/biological ordnance and improvised explosive devices; a procedure in Explosive Ordnance Management.

Explosive Safety Quantity-Distance (ESQD)—the quantity of explosive material and distance separation relationships providing defined types of protection based on levels of risk considered acceptable.

Facilities—physical elements that can include roads, buildings, structures, and utilities. These elements are generally permanent or, if temporary, have been placed in one location for an extended period of time.

Fathom—a unit of length equal to 6 feet; used to measure the depth of water.

Feature—in archaeology, a non-portable portion of an archaeological site, including such facilities as fire pits, storage pits, stone circles, or foundations.

Federal Candidate Species—taxa for which the U.S. Fish and Wildlife Service has on file sufficient information on biological vulnerability and threat(s) to support proposals to list them as endangered or threatened species.

Fee Simple Land—land held absolute and clear of any condition or restriction, and where the owner has unconditional power of disposition.

Feral—having escaped from domestication and become wild.

Fleet Area Control and Surveillance Facility (FACSFAC)—Navy facility that provides air traffic control services and controls and manages Navy-controlled off-shore operating areas and instrumented ranges.

Fleet Response Training Plan (FRTP)—the 27-month cycle that replaces the Interdeployment Training Cycle. The FRTP includes four phases prior to deployment: Maintenance, Unit Level Training, Integrated Training, and Sustainment.

Fleet Response Plan/Fleet Readiness Program (FRP)—the Fleet Response Plan was the Navy's response to the 2002/2003 international situations in Afghanistan and Iraq. The Fleet Readiness Program was later developed by the Fleet commanders. Both names refer to the same operational construct. The FRP is designed to more rapidly develop and then sustain readiness in ships and squadrons so that, in a national crisis or contingency operation, the Navy can quickly surge significant combat power to the scene.

Flight Level—a level of constant atmospheric pressure related to a reference datum of 29.92 inches of mercury stated in three digits that represent hundreds of feet. For example, flight level 250 represents a barometric altimeter indication of 25,000 feet; flight level 255 represents an indication of 25,500 feet.

Flight Termination—action taken in certain post-launch situations, such as a missile veering off of its predicted flight corridor; accomplished by stopping the propulsive thrust of a rocket motor via explosive charge. At this point, the missile continues along its current path, falling to earth under gravitational influence.

Floodplain—the lowland and relatively flat areas adjoining inland and coastal waters including flood prone areas of offshore islands; includes, at a minimum, that area subject to a 1 percent or greater chance of flooding in any given year (100-year floodplain).

Free Flight—a joint initiative of the aviation industry and the Federal Aviation Administration to allow aircraft to take advantage of advanced satellite voice and data communication to provide faster and more reliable transmission to enable reductions in vertical, lateral, and longitudinal separation of aircraft, more direct flights and tracts, and faster altitude clearance. It will allow pilots, whenever practicable, to choose their own route and file a flight plan that follows the most efficient and economical route, rather than following the published preferred instrument flight rules routes.

Frequent User—a unit that conducts training and exercises in the training areas on a regular basis but does not maintain a permanent presence.

Fugitive Dust—any solid particulate matter that becomes airborne, other than that emitted from an exhaust stack, directly or indirectly as a result of the activities of man. Fugitive dust may include emissions from haul roads, wind erosion of exposed soil surfaces, and other activities in which soil is either removed or redistributed.

Ground Hazard Area—the land area contained in an arc within which all debris from a terminated launch will fall. For example, the arc for a Strategic Target System launch is described such that the radius is approximately 10,000 feet to the northeast, 9,100 feet to the east, and 9,000 feet to the south of the launch point. For the Vandal launch, the arc is 6,000 feet.

Groundwater Table—the highest part of the soil or underlying rock material that is wholly saturated with water.

Groundwater—water within the earth that supplies wells and springs; specifically, water in the zone of saturation where all openings in rocks and soil are filled, the upper surface of which forms the water table.

Habitat—the area or type of environment in which a species or ecological community normally occurs.

Hazardous Air Pollutants—other pollutants, in addition to those addressed by the NAAQS, that present the threat of adverse effects to human health or to the environment as covered by Title III of the Clean Air Act. Incorporates, but is not limited to, the pollutants controlled by the National Emissions Standards for Hazardous Air Pollutants program.

Hazardous Material—generally, a substance or mixture of substances capable of either causing or significantly contributing to an increase in mortality or an increase in serious irreversible or incapacitating reversible illness; it may pose a threat or a substantial present or potential risk to human health or the environment. Hazardous materials use is regulated by the U.S. Department of Transportation, the Occupational Safety and Health Administration, and the Emergency Right-to-Know Act.

Hazardous Waste—a waste, or combination of wastes, which, because of its quantity, concentration, or physical, chemical, or infectious characteristics, may either cause or significantly contribute to an increase in mortality or an increase in serious irreversible illness or pose a substantial present or potential hazard to human health or the environment when improperly treated, stored, transported, disposed of, or otherwise managed.

Hertz (Hz)—the standard radio equivalent of frequency in cycles per second of an electromagnetic wave. Kilohertz (kHz) is a frequency of 1,000 cycles per second. Megahertz (MHz) is a frequency of 1 million cycles per second.

High Explosive (HE)—used when describing explosive ordnance, i.e., ordnance typically used in combat or possessing same or similar explosive-filler as combat ordnance; example – 20mm through 2,000LB Mk-80 series HE.

Historic Properties—under the National Historic Preservation Act, these are properties of national, state, or local significance in American history, architecture, archaeology, engineering, or culture, and worthy of preservation

Host—the Facilities Host holds plant account of all Class I (Land) and most Class II (Buildings) property. The Operational Host determines and executes operational policy for the range/range complex.

Hydraulic Conductivity—the rate in gallons per day water flow through a cross section of one square foot under a unit hydraulic gradient, at the prevailing temperature.

Hydrocarbons—any of a vast family of compounds containing hydrogen and carbon, including fossil fuels.

Hydrochloric Acid—a common chemical component of missile exhaust believed to injure plant leaves and affect wildlife.

Hydrology—the science dealing with the properties, distribution, and circulation of water on the face of the land (surface water) and in the soil and underlying rocks (groundwater).

Hydrophone—an instrument for listening to sound transmitted through water.

Impact Area—the identified area within a range intended to capture or contain ammunition, munitions, or explosives and resulting debris, fragments, and components from various weapon system employments.

Impacts (effects)—an assessment of the meaning of changes in all attributes being studied for a given resource; an aggregation of all the adverse effects, usually measured using a qualitative and nominally subjective technique. In this Environmental Impact Statement, as well as in the Council on Environmental Quality regulations, the word impact is used synonymously with the word effect.

Indurated—rendered hard, as in dunes where surface sand is loose, but subsurface areas become increasingly compact (see lithified).

Infrastructure—the system of public works of a country, state, or region, such as utilities or communication systems; physical support systems and basic installations needed to operate a particular area or facility.

In-Shore—lying close to the shore or coast.

Instrument Flight Rules (IFR)—rules governing the procedures for conducting instrument flight; it is a term used by pilots and controllers to indicate type of flight plan.

Interdeployment Readiness Cycle—the period by which Naval units progress through maintenance/unit level training, integrated training, and sustainment training stages prior to being deployed with the Fleet to support the gaining CINC.

Intermittent User—a unit that conducts training and exercises in the training areas throughout the year, but not on a regularly scheduled basis, and does not maintain a permanent presence.

International Waters—sea areas beyond 12 nm of the U.S. shoreline.

Intertidal Zone—occupies the space between high and low tide, also referred to as the littoral zone; found closest to the coastal fringe and thus only occurring in shallow depths.

Ionizing Radiation—particles or photons that have sufficient energy to produce direct ionization in their passage through a substance. X-rays, gamma rays, and cosmic rays are forms of ionizing radiation.

Isobath—the line on a marine map or chart joining points of equal depth, usually in fathoms below mean sea level.

Jet Routes—a route designed to serve aircraft operating from 18,000 feet (5,486 meters) up to and including flight level 450, referred to as J routes with numbering to identify the designated route.

Land/Sea Use—the exclusive or prioritized commitment of a land/sea area, and any targets, systems, and facilities therein, to a continuing purpose that could include a grouping of operations, buffer zone, environmental mitigation, etc. The land/sea area may consist of a range/range complex, grouping of similar facilities, or natural resource-based area with no facilities.

Lead—a heavy metal which can accumulate in the body and cause a variety of negative effects; one of the six pollutants for which there is a national ambient air quality standard (see Criteria Pollutants).

Lead-based Paint—paint on surfaces with lead in excess of 1.0 milligram per square centimeter as measured by X-ray fluorescence detector, or 0.5 percent lead by weight.

Leptocephalic—small, elongate, transparent, planktonic.

Level of Service (LOS)—describes operational conditions within a traffic stream and how they are perceived by motorists and/or passengers; a monitor of highway congestion that takes into account the average annual daily traffic, the specified road segment's number of lanes, peak hour volume by direction, and the estimated peak hour capacity by a roadway's functional classification, area type, and signal spacing.

Lithified—the conversion of newly deposited sediment into an indurated rock.

Littoral—species found in tide pools and near-shore surge channels.

Loam—a loose soil composed of a mixture of clay, silt, sand, and organic matter.

Long-Term Sustainability of Department of Defense Ranges—the ability to indefinitely support national security objectives and the operational readiness of the Armed Forces, while still protecting human health and the environment.

Major Exercise—a significant operational employment of live, virtual, and/or constructive forces during which live training is accomplished. A Major Exercise includes multiple training objectives, usually occurring over an extended period of days or weeks. An exercise can have multiple training operations (sub-events each with its own mission, objective and time period. Examples include C2X, JTFEX, SACEX, and CAX. Events (JTFEX) are composed of specific operations (e.g., Air-to-Air Missile), which consist of individual activities (e.g., missile launch).

Maneuver Area—range used for maneuver element training.

Maneuver Element—basic element of a larger force independently capable of maneuver. Normally, a Marine Division recognizes its infantry battalions, tank battalion, and light armored reconnaissance (LAR) battalion as maneuver elements. A rifle (or tank/LAR) battalion would recognize its companies as maneuver elements. A rifle (or tank/LAR) company would recognize its platoons as maneuver elements. Maneuver below the platoon level is not normally possible since fire and movement can be combined only at the platoon level or higher. The Army and National Guard recognize a squad and platoon as maneuver elements.

Maneuver—employment of forces on the battlefield through movement in combination with fire, or fire potential, to achieve a position of advantage with respect to the enemy in order to accomplish the mission.

Marine Corps Ground Unit—Marine Expeditionary Unit Ground Combat Element, or Battalion Landing Team, composed of an infantry battalion of about 1,200 personnel reinforced with artillery, amphibious assault vehicles, light armored reconnaissance assets and other units as the mission and circumstances require. (The analysis will scale units of different size or composition from this Battalion Landing Team standard unit to include a 12-man Special Operations platoon.)

Maritime—of, relating to, or bordering on the sea.

Material Safety Data Sheet—presents information, required under Occupational Safety and Health Act standards, on a chemical's physical properties, health effects, and use precautions.

Medical Evacuation—emergency services, typically aerial, designed to remove the wounded or severely ill to medical facilities.

Mesopelagic—the oceanic zone from 109 to 547 fathoms (656 to 3,280 feet).

Migration—repeated departure and return of individuals and their offspring to and from an area.

Migratory Birds—birds characterized by their practice of passing, usually periodically, from one region or climate to another.

Military Expended Material (MEM)—For the purpose of this policy, refers to those munitions, items, devices, equipment and materials which are uniquely military in nature, and are used and expended in the conduct of the military training and testing mission, such as: sonobuoys, flares, chaff, drones, targets, bathymetry measuring devices and other instrumentation, communications devices, and items used as training substitutes. This definition may also include materials expended (such as propellants, weights, guidance wires) from items typically recovered, such as aerial target drones and practice torpedoes.

Military Expended Material Constituent (MEMC)—Any constituent released into the environment from the use of MEM. This definition also includes constituents from explosive and non-explosive materials and the emission, degradation, or breakdown products from such MEM.

Military Operating Area—airspace below 18,000 feet used to separate or segregate certain non-hazardous military flight activities from Instrument Flight Rules traffic and to identify for Visual Flight Rules traffic where these activities are conducted.

Military Training Route—an airspace corridor established for military flight training at airspeeds in excess of 250 nautical miles/hour.

Minority—minority populations, as reported by the 2000 Census of Population and Housing, includes Black, American Indian, Eskimo or Aleut, Asian or Pacific Islander, Hispanic, or other.

Mitigation—a method or action to reduce or eliminate adverse environmental impacts. Such measures may avoid impacts by not taking a certain action or parts of an action; minimize impacts by limiting the magnitude of an action; rectify impacts by restoration measures; reduce or eliminate impacts over time by preservation or maintenance measures during the action; or compensate for impacts by replacing or providing substitute resources or environments.

Mobile Sources—any movable source that emits any regulated air pollutant.

Mortality—the number of deaths in a given time or place.

Munitions Constituents—any materials originating from unexploded ordnance, discarded military munitions, or other military munitions, including explosive and non-explosive materials, and emission, degradation, or breakdown elements of such ordnance or munitions.

National Airspace System—the common network of U.S. airspace; air navigation facilities, equipment and services, airports or landing areas; aeronautical charts, information and services; rules, regulations and procedures, technical information, and manpower and material. Included are system components shared jointly with the military.

National Ambient Air Quality Standards (NAAQS)—as set by the Environmental Protection Agency under Section 109 of the Clean Air Act, nationwide standards for limiting concentrations of certain widespread airborne pollutants to protect public health with an adequate margin of safety (primary standards) and to protect public welfare, including plant and animal life, visibility and materials (secondary standards). Currently, six pollutants are regulated by primary and secondary NAAQS: carbon monoxide, lead, nitrogen dioxide, ozone, particulate matter, and sulfur dioxide (see Criteria Pollutants).

National Environmental Policy Act (NEPA)—Public Law 91-190, passed by Congress in 1969. The Act established a national policy designed to encourage consideration of the influences of human activities, such as population growth, high-density urbanization, or industrial development, on the natural environment. The National Environmental Policy Act procedures require that environmental information be made available to the public before decisions are made. Information contained in the National Environmental Policy Act documents must focus on the relevant issues in order to facilitate the decision-making process.

National Register of Historic Places Eligible Property—property that has been determined eligible for the National Register of Historic Places listing by the Secretary of the Interior, or one that has not yet gone through the formal eligibility determination process but which meets the National Register of Historic Places criteria for section review purposes; eligible properties are treated as if they were already listed.

National Register of Historic Places—a register of districts, sites, buildings, structures, and objects important in American history, architecture, archaeology, and culture, maintained by the Secretary of the Interior under authority of Section 2 (b) of the Historic Sites Act of 1935 and Section 101 (a)(1) of the National Historic Preservation Act of 1966, as amended.

National Wildlife Refuge—a part of the national network of refuges and wetlands managed by the U.S. Fish and Wildlife Service in order to provide, preserve, and restore lands and waters sufficient in size, diversity and location to meet society's needs for areas where the widest possible spectrum of benefits associated with wildlife and wildlands is enhanced and made available. This includes 504 wildlife refuges nationwide encompassing 92 million acres and ranging in size from one-half acre to thousands of square miles. Dedicated to protecting wildlife and their habitat, U.S. refuges encompass numerous ecosystems and are home to a wide variety of fauna, including large numbers of migratory birds and some 215 threatened or endangered species.

Native Americans—used in a collective sense to refer to individuals, bands, or tribes who trace their ancestry to indigenous populations of North America prior to Euro-American contact.

Native Species—plants or animals living or growing naturally in a given region and often referred to as indigenous.

Native Vegetation—often referred to as indigenous, these are plants living or growing naturally in a given region without agricultural or cultivational efforts.

Navigational Aid—any visual or electronic device, airborne or on the surface, which provides point-to-point guidance information or position data to aircraft in flight.

Near-Shore—an indefinite zone that extends seaward from the shoreline.

Neritic—relating to the shallow ocean waters, usually no deeper than 109 fathoms (656 feet).

Nitrogen Dioxide—gas formed primarily from atmospheric nitrogen and oxygen when combustion takes place at high temperatures.

Nitrogen Oxides—gases formed primarily by fuel combustion and which contribute to the formation of acid rain. In the presence of sunlight, hydrocarbons and nitrogen oxides combine to form ozone, a major constituent of photochemical smog.

Nonattainment Area—an area that has been designated by the U.S. Environmental Protection Agency or the appropriate state air quality agency as exceeding one or more of the national or state ambient air quality standards.

Non-directional Radio Beacon—a radio beacon transmitting non-directional signals whereby the pilot of an aircraft equipped with direction finding equipment can determine the aircraft's bearing to or from the radio beacon and “home” on or track to or from the station.

Non-explosive, Practice Munitions (NEPM)—used when describing most common types of practice ordnance. However, non-explosive, practice munitions may contain spotting charges or signal cartridges for impact locating purposes (smoke charges for daylight spotting, flash charges for night spotting); example - MK-76, BDU-45. Some non-explosive, practice munitions may also contain unburned propellant (such as rockets).

Non-ionizing Radiation—electromagnetic radiation at wavelengths whose corresponding photon energy is not high enough to ionize an absorbing molecule. All radio frequency, infrared, visible, and near ultraviolet radiation are non-ionizing.

Non-Point Source Pollution—diffuse pollution; that is, from a combination of sources; typically originates from rain and melted snow flowing over the land (runoff). As runoff contacts the land's surface, it picks up many pollutants in its path: sediment, oil and grease, road salt, fertilizers, pesticides, nutrients, toxics, and other contaminants. Runoff also originates from irrigation water used in agriculture and on landscapes. Other types of non-point pollution include changes to the natural flow of water in stream channels or wetlands.

Notice to Airmen (NOTAM)—a notice containing information, not known sufficiently in advance to publicize by other means, the establishment, condition, or change in any component (facility, service, or procedure of, or hazard in the National Airspace System), the timely knowledge of which is essential to personnel concerned with flight operations.

Notice to Mariners (NOTMAR)—a periodic notice regarding changes in aids to navigation, dangers to navigation and other information essential to mariners.

Off-Shore—open-ocean waters over the continental slope which are deeper than 200 meters, beyond the continental shelf break.

Operating Area (OPAREA)—ocean area not part of a range used by military personnel or equipment for training and weapons system Research, Development, Test & Evaluation (RDT&E).

Operation—A combination of activities accomplished together for a scheduled period of time for an intended military mission or task. An operation can range in size from a single unit exercise to a Joint or Combined event with many participants (e.g., aircraft, ships, submarines, troops).

Operational Range—a range that is under the jurisdiction, custody, or control of the Secretary of Defense and is used for range activities; or although not currently being used for range activities, that is still considered by the Secretary to be a range and has not been put to a new use that is incompatible with range activities.

Ordnance—military supplies including weapons, ammunition, combat vehicles, and maintenance equipment.

OTTO Fuel—a torpedo fuel.

Ozone (O_3)—a highly reactive form of oxygen that is the predominant component of photochemical smog and an irritating agent to the respiratory system. Ozone is not emitted directly into the atmosphere but results from a series of chemical reactions between oxidant precursors (nitrogen oxides and volatile organic compounds) in the presence of sunlight.

Ozone Layer—a naturally occurring layer of ozone 7 to 30 miles above the earth's surface (in the stratosphere) which filters out the sun's harmful ultraviolet radiation. It is not affected by photochemical smog found in the lower atmosphere, nor is there any mixing between ground level ozone and ozone in the upper atmosphere.

Paleontological Resources—fossilized organic remains from past geological periods.

Paleontology—the study of life in the past geologic time, based on fossil plants and animals.

Participant—an individual ship, aircraft, submarine, amphibious vehicle, or ground unit.

Particulate Matter, Fine Respirable—finely divided solids or liquids less than 10 microns in diameter which, when inhaled, remain lodged in the lungs and contribute to adverse health effects.

Particulate Matter, Total Suspended—finely divided solids or liquids ranging from about 0.1 to 50 microns in diameter which comprise the bulk of the particulate matter mass in the atmosphere.

Particulate Matter—particles small enough to be airborne, such as dust or smoke (see Criteria Pollutants).

Payload—any non-nuclear and possibly propulsive object or objects, weighing up to 272.2 kilograms (600 pounds), which are carried above the Strategic Target System third stage.

Pelagic Zone—commonly referred to as the open ocean.

Pelagic—of the ocean waters.

Peninsula—a portion of land nearly surrounded by water and generally connected with a larger body by an isthmus, although the isthmus is not always well defined.

Per Capita—per unit of population; by or for each person.

Permeability—a quality that enables water to penetrate.

Pesticide—any substance, organic, or inorganic, used to destroy or inhibit the action of plant or animal pests; the term thus includes insecticides, herbicides, fungicides, rodenticides, miticides, fumigants, and repellents. All pesticides are toxic to humans to a greater or lesser degree. Pesticides vary in biodegradability.

pH—a measure of the acidity or alkalinity of a solution, numerically equal to 7 for neutral solutions, increasing with increasing alkalinity and decreasing with increasing acidity.

Photosynthesis—the plant process by which water and carbon dioxide are used to manufacture energy-rich organic compounds in the presence of chlorophyll and energy from sunlight.

Physiography—geography dealing with the exterior physical features and changes of the earth (also known as physical geography).

Phytoplankton—plant-like organisms that drift with the ocean currents, with little ability to move through the water on their own. Predominately one-celled, phytoplankton float in the photic zone (sunlit surface waters of the ocean, which extends to only about 100 meters (330 feet) below the surface), where they obtain sunlight and nutrients, and serve as food for zooplankton and certain larger marine animals.

Pinniped—having finlike feet or flippers, such as a seal or walrus.

Plankton—free-floating, usually minute, organisms of the sea; includes larvae of benthic species.

Pliocene—of, relating to, or being the latest epoch of the Tertiary Period or the corresponding system of rocks; following the Pleistocene and prior to the Miocene.

PM-2.5 and PM-10—standards for measuring the amount of solid or liquid matter suspended in the atmosphere; refers to the amount of particulate matter less than or equal to 2.5 and 10 micrometers in diameter, respectively. The PM-2.5 and PM-10 particles penetrate to the deeper portions of the lungs, affecting sensitive population groups such as children and people with respiratory or cardiac diseases.

Point Source—a distinct and identifiable source, such as a sewer or industrial outfall pipe, from which a pollutant is discharged.

Population Density—the average number of individuals or organisms per unit of space or area.

Potable Water—water that is safe to drink.

Prehistoric—literally, "before history," or before the advent of written records. In the old world writing first occurred about 5400 years ago (the Sumerians). Generally, in North America and the Pacific region, the prehistoric era ended when European explorers and mariners made written accounts of what they encountered. This time will vary from place to place.

Prohibited Area—designated airspace where aircraft are prohibited, except by special permission. Can also apply to surface craft.

Radar—a radio device or system for locating an object by means of radio waves reflected from the object and received, observed, and analyzed by the receiving part of the device in such a way that characteristics (such as distance and direction) of the object may be determined.

Range—a land or sea area designated and equipped for any or all of the following reasons:

Range Activity—an individual training or test function performed on a range or in an Operating Area. Examples include missile launching, bombardment, and vehicle driving. Individual RDT&E functions are also included in this category.

Range Complex—a geographically integrated set of ranges, operational areas, and associated special use airspace, designated and equipped with a command and control system and supporting infrastructure for freedom of maneuver and practice in munitions firing and live ordnance use against scored and/or tactical targets and/or Electronic Warfare tactical combat training environment.

Range Operation—a live training exercise, RDT&E test, or field maneuver conducted for a specific strategic, operational or tactical military mission, or task. A military action. Operations may occur independently, or multiple operations may be accomplished as part of a larger event. One operation consists of a combination of activities accomplished together. The type of operation can include air, land, sea, and undersea warfare training or testing. Participants can include a specific number and type of aircraft, ships, submarines, amphibious or other vehicles and personnel. Ordnance broadly encompasses all weapons, missiles, shells, and expendables (chaff and flares). An individual operation occurs over a given geographic footprint for a scheduled period of time. An example is a Mining Operation. Each Mining Operation is discrete and relatively short in duration, but it may be combined with other operations in a single, larger exercise, like a JTFEX, which lasts for several days or weeks.

Range Safety Zone—area around air-to-ground ranges designed to provide safety of flight and personnel safety relative to dropped ordnance and crash sites. Land use restrictions can vary depending on the degree of safety hazard, usually decreasing in magnitude from the weapons impact area (including potential ricochet) to the area of armed over flight and aircraft maneuvering.

Readiness—the ability of forces, units, weapon systems, or equipment to deliver the outputs for which they were designed (includes the ability to deploy and employ without unacceptable delays).

Region of Influence—the geographical region that would be expected to be affected in some way by the Proposed Action and alternatives.

Relative Humidity—the ratio of the amount of water vapor actually present in the air to the greatest amount possible at the same temperature.

Relief—the difference in elevation between the tops of hills and the bottoms of valleys.

Remediation—all necessary actions to investigate and clean up any known or suspected discharge or threatened discharge of contaminants, including without limitation: preliminary assessment, site investigations, remedial investigations, remedial alternative analyses and remedial actions.

Restricted Area—a designated airspace in which flights are prohibited during published periods of use unless permission is obtained from the controlling authority.

Runoff—the portion of precipitation on land that ultimately reaches streams, often with dissolved or suspended materials.

Safety Zone—administratively designated/implied areas designated to limit hazards to personnel and the public, and resolve conflicts between operations. Can include range safety zones, ESQDS, surface danger zones, special use airspace, HERO/HERP areas, etc.

Saline—consisting of or containing salt.

Sampling—the selection of a portion of a study area or population, the analysis of which is intended to permit generalization of the entire population. In archaeology, samples are often used to reduce the amount of land area covered in a survey or the number of artifacts analyzed from a site. Statistical sampling is generally preferred since it is possible to specify the bias or probability of error in the results, but judgmental or intuitive samples are sometimes used.

Scoping—a process initiated early during preparation of an Environmental Impact Statement to identify the scope of issues to be addressed, including the significant issues related to the Proposed Action. During scoping, input is solicited from affected agencies as well as the interested public.

Seamount—a peaked, underwater mountain that rises at least 3,281 feet above the ocean floor.

Seawall—a wall or embankment to protect the shore from erosion or to act as a breakwater.

Security Zone—area where public or non-operational support access is prohibited due to training operations of a classified or hazardous nature.

Sensitive Habitats—areas of special importance to regional wildlife populations or protected species that have other important biological characteristics (for example, wintering habitats, nesting areas, and wetlands).

Sensitive Receptor—an organism or population of organisms sensitive to alterations of some environmental factor (such as air quality or sound waves) that undergo specific effects when exposed to such alteration.

Short-Term Public Exposure Guidance Level—an acceptable concentration for unpredicted, single, short-term, emergency exposure of the general public, as published by the National Research Council.

Site—in archaeology, any location where human beings have altered the terrain or have discarded artifacts.

Solid Waste—municipal waste products and construction and demolition materials; includes non-recyclable materials with the exception of yard waste.

Sonobuoy—A floating sensor (sonar) device fitted with sensitive microphones and a radio used for searching, localization, tracking, and communication. Sonobuoys can be active or passive. Active sonobuoys can provide either a deployable acoustical signal source (DICASS) or an explosive signal source (IEER/AEER/EER). All sonobuoys receive underwater signals of interest and relay the signals.

Sortie—a single operational training or RDT&E event conducted by one aircraft tin a range or operating area. A single aircraft sortie is one complete flight (i.e., one take-off and one final landing).

Special Use Airspace—consists of several types of airspace used by the military to meet its particular needs. Special use airspace consists of that airspace wherein activities must be confined because of their nature, or wherein limitations are imposed upon aircraft operations that are not a part of these activities, or both. Special use airspace, except for Control Firing Areas, are chartered on instrument flight rules or visual flight rules charts and include hours of operation, altitudes, and the controlling agency.

Species—a taxonomic category ranking immediately below a genus and including closely related, morphologically similar individuals which actually or potentially interbreed.

Specific Absorption Rate—the time rate at which radio frequency energy is absorbed per unit mass of material, usually measured in watts per kilogram (W/kg).

Stakeholder—those people or organizations that are affected by or have the ability to influence the outcome of an issue. In general this includes regulators, the regulated entity, and the public. It also includes those individuals who meet the above criteria and do not have a formal or statutorily defined decision-making role.

State Historic Preservation Officer (SHPO)—the official within each state, authorized by the state at the request of the Secretary of the Interior, to act as liaison for purposes of implementing the National Historic Preservation Act.

State Jurisdictional Waters—sea areas within 3 nm of a state's continental and island shoreline.

Stationary Source—any building, structure, facility, installation, or other fixed source that emits any regulated air pollutant.

Stormwater—runoff produced during storms, generally diverted by rain spouts and stormwater sewerage systems. Stormwater has the potential to be polluted by such sources as yard trimmings and pesticides. A stormwater outfall refers to the mouth of a drain or sewer that channels this runoff.

Subsistence Economy—a community, usually based on farming and/or fishing, that provides all or most of the basic goods required by its members for survival, usually without any significant surplus for sale.

Subsistence—the traditional harvesting of natural resources for food, clothing, fuel, transportation, construction, art, crafts, sharing, and customary trade.

Subspecies—a geographically defined grouping of local populations which differs taxonomically from similar subdivisions of species.

Substrate—the layer of soil beneath the surface soil; the base upon which an organism lives.

Sulfur Dioxide—a toxic gas that is produced when fossil fuels, such as coal and oil, are burned.

Sustainable Range Management—management of an operational range in a manner that supports national security objectives, maintains the operational readiness of the Armed Forces, and ensures the long-term viability of operational ranges while protecting human health and the environment.

Sustaining the Capability—maintaining necessary skills, readiness and abilities.

Symbiotic—living in or on the host.

System of Systems—all communications, electronic warfare, instrumentation, and systems linkage supporting the range/range complex.

Taking—to harass, harm, pursue, hunt, shout, wound, kill, trap, capture, or collect, or attempt to engage in any such conduct. Taking can involve harming the habitat of an endangered species.

Targets—earthwork, materials, actual or simulated weapons platforms (tanks, aircraft, EW systems, vehicles, ships, etc.) comprising tactical target scenarios within the range/range complex impact areas. Could also include SEPTAR, AQM, BQM, MQM, etc.

Tenant—a unit that has an Inter-Service Support Agreement with the host for use of the training areas and that maintains a permanent presence.

Thermocline—a thin, narrow region in a thermally stratified body of water which separates warmer, oxygen-rich surface water from cold, oxygen-poor deep water and in which temperature decreases rapidly with depth. In tropical latitudes, the thermocline is present as a permanent feature and is located 200 to 1,000 feet below the surface.

Threatened Species—a plant or animal species likely to become endangered in the foreseeable future.

Topography—the configuration of a surface including its relief and the position of its natural and man-made features.

Traditional Resources—prehistoric sites and artifacts, historic areas of occupation and events, historic and contemporary sacred areas, material used to produce implements and sacred objects, hunting and gathering areas, and other botanical, biological, and geographical resources of importance to contemporary groups.

Transient—remaining a short time in a particular area.

Troposphere—the atmosphere from ground level to an altitude of 6.2 to 9.3 miles (see stratosphere).

Turbid—the condition of being thick, cloudy, or opaque as if with roiled sediment; muddy.

Uncontrolled Airspace—airspace of defined dimensions in which no air traffic control services to either instrument flight rules or visual flight rules aircraft will be provided, other than possible traffic advisories when the air traffic control workload permits and radio communications can be established.

Understory—a vegetal layer growing near the ground and beneath the canopy of a taller layer.

Unique and Sensitive Habitats—areas of special importance to regional wildlife populations or protected species that have other important biological characteristics (for example, wintering habitats, nesting areas, and wetlands).

Upland—an area of land of higher elevation.

Upwelling—the replenishing process of upward movement to the surface of marine often nutrient-rich lower waters (a boon to plankton growth), especially along some shores due to the offshore drift of surface water as from the action of winds and the Coriolis force.

U.S. Territorial Waters—sea areas within 12 nm of the U.S. continental and island shoreline.

Viewshed—total area seen within the cone of vision from a single observer position, or vantage point; a collection of viewpoints with optimal linear paths of visibility.

Vista—a distant view through or along an avenue or opening.

Visual Flight Rules (VFR)—rules that govern the procedures for conducting flight under visual conditions; used by pilots and controllers to indicate type of flight plan.

Volatile Organic Compound (VOC)—one of a group of chemicals that react in the atmosphere with nitrogen oxides in the presence of heat and sunlight to form ozone; it does not include methane and other compounds determined by the Environmental Protection Agency to have negligible photochemical reactivity. Examples of volatile organic compounds include gasoline fumes and oil-based paints.

Warning Area—a designated airspace in which flights are not restricted but avoidance is advised during published times of use.

Wastewater—water that has been previously utilized; sewage.

Wetlands—lands or areas that either contain much soil moisture or are inundated by surface or groundwater with a frequency sufficient to support a prevalence of vegetative or aquatic life that requires saturated or seasonally saturated soil conditions for growth and reproduction. Wetlands generally include such areas as bogs, marshes, mud and tidal flats, sloughs, river overflows, seeps, springs, or swamps.

Yearly Average Day-Night Sound Level (DNL or L_{dn})—utilized in evaluating long-term environmental impacts from noise, this is an annual mean of the day-night sound level.

Zoning—the division of a municipality (or county) into districts for the purpose of regulating land use, types of buildings, required yards, necessary off-street parking, and other prerequisites to development. Zones are generally shown on a map, and the text of the zoning ordinance specifies requirements for each zoning category.

Zooplankton—animals that drift with the ocean currents, with little ability to move through the water on their own, ranging from one-celled organisms to jellyfish up to 1.8 meters (6 feet) wide. Zooplankton live in both surface and deep waters of the ocean; crustaceans make up about 70 percent. While some float about freely throughout their lives, many spend only the early part of their lives as plankton.

This Page Intentionally Left Blank

CHAPTER 9 LIST OF PREPARERS

Government Contributors/Reviewers:

CDR Dan Eldredge, JAGC, USN
U.S. Pacific Fleet Environmental Counsel

Edward J Lynch, CDR JAGC USN (ret)
Kaya Associates, Inc
US Pacific Fleet EIS Project Manager
Juris Doctor, 1978

Nora Macariola-See, P.E.
Navy Technical Representative
Naval Facilities Engineering Command Pacific
B.S. Chemical Engineering

Lori Mazzuca
Marine Resource Specialist
Naval Facilities Engineering Command

Julie Rivers
Fish and Wildlife Biologist
U.S. Pacific Fleet
B.S. Biology, 1989

Vanessa E. Pepi
Supervisory Fish and Wildlife Biologist
Naval Facilities Engineering Command Pacific
M.S. Animal Sciences (Evolution, Ecology and Conservation Biology)

List of Preparers:

Susan L. Bupp (Parsons Transportation Group), Cultural Resources Specialist
MA Anthropology, University of Wyoming, Laramie
BA Anthropology, Wichita State University
Years of Experience: 32
Sections: Cultural Resources

Rosemarie W. Crisologo (Parsons Infrastructure & Technology), Senior Environmental Planner
MS Environmental Engineering, University of Southern California
BS Biology, University of Southern California
Years of Experience: 26
Sections: Geology, Water Quality

Anthony Davis (Parsons Infrastructure & Technology), Principal Engineer
B.S. Civil Engineering, University of Missouri
Years of Experience: 30
Section: Hazardous Materials and Waste

Elvira V. Gaddi, P.E. (SRS-Parsons, Joint Venture), Principal Project Manager
MS Chemical Engineering, University of Idaho
BS Chemical Engineering, University of the Philippines
Years of Experience: 25
Sections: Hazardous Materials and Waste, Air Quality

Lawrence Honma (Merkel & Associates, Inc.), Marine Biology and Fish
B.S. Wildlife and Fisheries Biology, University of California, Davis
M.S. Marine Sciences, Moss Landing Marine Laboratory, California State University, San Francisco
Years of Experience: 18
Sections: Essential Fish Habitat

Taylor Houston (Parsons Infrastructure & Technology), Senior Biologist
MS Aquatic Biology (in progress), Texas State University
BA Natural Resource Management, University of Texas at Austin
Years of Experience: 10
Sections: Biological Resources, Biological Assessments, Marine Communities, Terrestrial Species and Habitats, Sea Turtles, Seabirds

Tammy Jo Mitnik (ManTech SRS Technologies, Inc.), Project Manager
M.B.A., Management, American InterContinental University
B.S., Justice and Public Safety, Auburn University
Years of Experience: 14
Sections: Chapters 4, 5, 6, Recreation, Transportation, Land Use, Demographics, Regional Economy, Environmental Justice

Jonathon Nicholls (ManTech SRS Technologies, Inc.), Military Operations Specialist
M.A. Business Management, National University
B.S. Applied Mathematics, University of North Dakota
Years of Experience: 24
Sections: Chapters 1, 2, Land Use

Jill Noel (Parsons Infrastructure & Technology), Senior Biologist
M.A. Botany , University of Texas at Austin
M.S. Plant Biology, Louisiana State University
Years of Experience: 8
Sections: Marine Mammals, Biological Assessment

John Pitcher (ManTech SRS Technologies, Inc.), Director, ESD Business Ops
M.B.A., Management, University of Virginia
B.S., Chemical Engineering, Massachusetts Institute of Technology
Years of Experience: 19
Program Manager

Molly Rodriguez (ManTech SRS Technologies, Inc.), Geospatial Analyst
BS: Geography, Pennsylvania State University
Years of Experience: 3
Sections: Transportation, GIS

Philip Thorson (ManTech SRS Technologies, Inc.), Senior Research Biologist/Marine Mammal Biologist
Ph.D. Biology, University of California at Santa Cruz
Years of Experience: 27
Sections: Marine Mammals

John Wallin (Parsons Infrastructure & Technology), Senior Environmental Planner
M.A. Management, Webster University
B.A. Biology
Years of Experience: 16
Sections: Public Health and Safety, Air Quality

Karl Whittenberg (ManTech SRS Technologies, Inc.), Project Manager
M.P.A. Public Management, The George Washington University
M.M.A.S. Military Strategy, U.S. Army Command and General Staff College
B.S. Basic Sciences, United States Air Force Academy
Years of Experience: 35
Sections: Transportation, Land Use

Lawrence Wolski (ManTech SRS Technologies, Inc.), Senior Subject Matter Expert
M.S. Marine Sciences, University of San Diego
B.S. Biology, Loyola Marymount University
Years of Experience: 12
Sections: Noise

This page intentionally left blank.

CHAPTER 10 DISTRIBUTION LIST

The individuals, agencies, and organizations listed in this Chapter received a compact disk (CD) with a copy of the Mariana Islands Range Complex Draft Environmental Impact Statement/Overseas Environmental Impact Statement.

Federal Agencies

EPA Region 9
Timonie Hood
Pacific Islands Office, 75 Hawthorne Street (CMD-6)
San Francisco CA 94105

EPA Region 9
Michael Wolfram
Pacific Islands Office,
75 Hawthorne Street (CMD-6)
San Francisco CA 94105

EPA Region 9 - Honolulu
Wendy Wiltse
300 Ala Moana Blvd., Rm. 5152, Box 50003
Honlulu HI 96850

Federal Aviation Administration
Randy Reeves
1775 Admiral Sherman Blvd.
Tiyan GU 96913

National Park Service
Sarah Creachbaum
Department of Interior
135 Murray Blvd
Hagatna GU 96910

National Park Service, War in the Pacific NHP
Superintendent
135 Murray Boulevard
Hagatna GU 96910

NOAA Fisheries Service
Bill Robinson
Pacific Islands Regional Administrator
1601 Kapiolani Blvd., Suite 1110
Honolulu HI 96814

NOAA Fisheries Service
Habitat Division
Gerry Davis
Assistant Regional Administrator for Habitat
1601 Kapiolani Blvd., Suite 1110
Honolulu HI 96814

NOAA Fisheries Service Habitat Division
John Naughton
NMFS HCD DoD Coordinator
1601 Kapiolani Blvd., Suite 1110
Honolulu HI 96814

NOAA Fisheries Service
Protected Resources Division
Arlene Pangelinan
Protected Resource Section 7 and DoD Liaison
1601 Kapiolani Blvd., Suite 1110
Honolulu HI 96814

NOAA Fisheries Service
Protected Resources Division
Chris Yates
Assistant Regional Administrator for Protected Resources
1601 Kapiolani Blvd., Suite 1110
Honolulu HI 96814

NOAA Fisheries, Pacific Islands Regional Office
Kay Zukeran
Pacific Islands Regional Administrator
1601 Kapiolani Blvd., Suite 1110
Honolulu HI 96814

NOAA National Marine Fisheries - CNMI Office
Tany Topalian
CNMI Field Office
P.O. Box 10007
Saipan MP 96950

NOAA National Marine Fisheries Service
Habitat Division - Guam Office
Valerie Brown
Coral Reef Ecologist
c/o DAWR 163 Dairy Road
Mangilao GU 96913

Office of Hawaiian Affairs
Haunani Apoliona
Chair of Board of Trustees
711 Kapiolani Boulevard, 12th Floor
Honolulu HI 96813

Office of Insular Affairs
R. Thomas Weimer
Department of Interior
1849 C Street
Washington DC 20240

U.S. Army Corps of Engineers
Guam Regulatory Branch
Frank Dayton
Environmental Engineer
PSC 455, Box 188
FPO AP 96540-1088

U.S. Army Corps of Engineers Honolulu District
Charles Klinge
Commander
Building 230
Fort Shafter HI 96858

U.S. Coast Guard
William Marhoffer
Office of Marine Safety - Captain of the Port
US Coast Guard Guam Sector GU PSC
455 Box 176 FPO AP GU 96540

U.S. Coast Guard Marianas Section
Dale Raush
Captain
PSC 455 Box 176
FPO AP GU 96540-1056

U.S. Department of Interior
Office of Solicitor
Carolyn Lowa
1111 Jackson St, Suite 735
Oakland CA 94607-4807

U.S. Environmental Islands Office, Protections
Agency, Pacific Region 9
John McCarroll
Pacific Islands Office, 75 Hawthorne Street (CMD-6)
San Francisco CA 94105

U.S. Fish & Wildlife Service
Earl Campbell
Invasive Species Division Coordinator
300 Ala Moana Blvd., Rm. 3122 Box 50088
Honolulu HI 96850

U.S. Fish & Wildlife Service
Michael Molina
Environmental Review Coordinator
300 Ala Moana Blvd., Rm. 3122 Box 50088
Honolulu HI 96850

U.S. Fish & Wildlife Service
Jeff Newman
Assistant Field Supervisor Habitat Consultation
Division
300 Ala Moana Blvd., Rm. 3122 Box 50088
Honolulu HI 96850

U.S. Fish & Wildlife Service - Guam
Arthur Campbell, Wildlife Inspector
415 Chalan San Antonio Rd, Baltej Pavilion, Ste 209
Tamuning GU 96913-3620

U.S. Fish and Wildlife Service
Christine Bandy
Guam Field Office
P.O. Box 8134 MOU-3
Dededo GU 96929

U.S. Fish and Wildlife Services, Pacific Islands Office
Paul Henson
Field Supervisor
300 ALA MOANA BLVD ROOM 3-122, Box 50088
Honolulu HI 96850

U.S. Fish and Wildlife Services, Pacific Islands Office
Dwayne Minton
Marine Ecology Specialist
300 ALA MOANA BLVD ROOM 3-122, Box 50088
Honolulu HI 96850

U.S. Fish and Wildlife Services, Pacific Islands
Office, Ecological Services Branch
Patrick Leonard
Field Supervisor
300 Ala Moana Blvd., Rm. 3-122, Box 50088
Honolulu HI 96850

USACE Honolulu District
Connie Ramsey
Ecologist
Building 230
Fort Shafter HI 96858

USACE Honolulu District
George Young
Chief Regulatory Branch
Building 230
Fort Shafter HI 96858

USDA Forest Service
Pacific Southwest Research Station
Institute of Pacific Islands Forestry
J. Boone Kaufman
Institute Director
1151 Punchbowl Street - Room 323
Honolulu HI 96813

USDA Natural Resource Conservation Service,
Pacific Basin Area
John H. Lawrence
Assistant Director
First Hawaiian Bank Building, Suite 301, 400 Route 8
Mongmong GU 96910-2003

USDA Natural Resources Conservation Service,
Saipan Service Center
James S. Crockett
District Conservationist
PO Box 5082 - CHRB
Saipan MP 96950-5082

USDA Wildlife Services
Craig Clark
Supervisory Wildlife Biologist
1060 Route 16, Suite 103C
Barrigada Heights GU 96913

USDA Wildlife Services
Daniel S. Vice
Assistant State Director
1060 Route 16, Suite 103C
Barrigada Heights GU 96913

State and Local Jurisdiction Agencies

Department of Agriculture
Aquatic and Wildlife Res.
Celestino F. Aguon
163 Dairy Rd
Mangilao GU 96913

Department of Military Affairs/
Guam Air National Guard
Franklin Leon Guerrero
Asst. Adjutant General
APO-AP AAFB 96543-4046

Department of Military Affairs/
Guam Army National Guard
Donald Goldhorn, Adjutant General
430 Route 16 Bldg. 300 Rm 113
Barrigada GU 96913-4421

Guam Bureau of Planning and Statistics
Coastal Management Program
Amelia F. De Leon
Planner
P.O. Box 2950
Hagatna GU 96932

Guam Bureau of Planning and Statistics
Coastal Management Program
Anthony Lamorena
Director
P.O. Box 2950
Hagåtña GU 96932

Guam Bureau of Planning and Statistics
Coastal Management Program
Evangeline D. Lujan
Administrator
P.O. Box 2950
Hagatna GU 96932

Guam Bureau of Planning and Statistics
Coastal Management Program
Teresita M. Perez
Planner
P.O. Box 2950
Hagatna GU 96932

Guam Chamorro Land Trust Commission
Thomas Elliott
Acting Administrator
P.O. Box 2950
Hagatna GU 96932

Guam Community College
Herominiano
Delos Santos
President
P.O. Box 23069
GMF GU 96921

Guam Department of Agriculture
Joseph Torres
Deputy Director
163 Dairy Road
Mangilao GU 96913

Guam Department of Agriculture,
Division of Aquatic and Wildlife Resources
Celestino "Tino" Aguon
Acting Chief
163 Dairy Road
Mangilao GU 96913

Guam Department of Agriculture,
Division of Aquatic and Wildlife Resources
Paul Bassler
Director
163 Dairy Road
Mangilao GU 96913

Guam Department of Agriculture,
Division of Aquatic and Wildlife Resources
David Gee, II
Brown Tree Snakes
163 Dairy Road
Mangilao GU 96913

Guam Department of Agriculture,
Division of Aquatic and Wildlife Resources
Jay Gutierrez, Assistant Chief
163 Dairy Road
Mangilao GU 96913

Guam Department of Agriculture,
Division of Aquatic and Wildlife Resources
Diane Vice
Project Leader, Brown Tree Snakes
163 Dairy Road
Mangilao GU 96913

Guam Department of Land Management
Joseph Borja, Director
PO Box 2950
Hagatna GU 96932

Guam Department of Parks and Recreation
Thomas Morrison
Director
490 Chalan Paliso
Agana Heights GU 96915

Guam Department of Public Works
Lawrence Perez
Acting Director
542 North Marine Corps Drive
Tamuning GU 96913

Guam Division of Forest and Soil Resources
David Limtiaco
Chief
163 Dairy Road
Mangilao GU 96913

Guam Division of Forest and Soil Resources
Joseph Tuquero
Forester III
163 Dairy Road
Mangilao GU 96913

Guam Economic Development
and Commerce Authority
Andy Jordanou
Administrator
590 South Marine Drive, ITC Building Suite 511
Tamuning GU 96913

Guam Environmental Protection Agency
Lorilee Crisostomo
Administrator
P.O. Box 22439 GMF
Barrigada GU 96921

Guam Environmental Protection Agency
Benny Cruz
Program Director, Water Resources Management
P.O. Box 22439 GMF
Barrigada GU 96921

Guam Environmental Protection Agency
Mike Gawel
Environmental Planner
P.O. Box 22439 GMF
Barrigada GU 96921

Guam Environmental Protection Agency
Walt Leon Guerrero
DSMOA
P.O. Box 22439 GMF
Barrigada GU 96921

Guam Environmental Protection Agency
Manuel Minas
Program Director, Water Pollution Control
P.O. Box 22439 GMF
Barrigada GU 96921

Guam Environmental Protection Agency
Randel Sablan
Chief Planner - Environmental Planning and Review
P.O. Box 22439 GMF
Barrigada GU 96921

Guam Environmental Protection Agency
Conchita Taitano
Air & Land Programs Division Administrator
P.O. Box 22439 GMF
Barrigada GU 96921

Guam Environmental Protection Agency
Water Resources Management Program
Angel Marquez
P.O. Box 22439 GMF
Barrigada GU 96921

Guam Historic Preservation Office
Dept. of Parks & Recreation
Jayna Boya
490 Chalan Palasyo
Agana Heights GU 96910

Guam Historic Preservation Office
Dept. of Parks & Recreation
Guillom Hernandez
490 Chalan Palasyo
Agana Heights GU 96910

Guam Historic Preservation Office
Dept. of Parks & Recreation
Patrick Lujan
490 Chalan Palasyo
Agana Heights GU 96910

Guam Historic Resources Division
(Historic Preservation Office)
Lynda Aguon
Guam Historic Preservation Officer
Department of Parks and Recreation
490 Chalan Palasyo
Agana Heights GU 96910

Guam Historic Resources Division
(Historic Preservation Office)
Vic April
State Archeologist
Department of Parks and Recreation, 490 Chalan Palasyo
Agana Heights GU 96910

Guam Historic Resources Division
(Historic Preservation Office)
Joe Garrido
Historic Preservation Specialist III
Department of Parks and Recreation
490 Chalan Palasyo
Agana Heights GU 96910

Guam Historic Resources Division
(Historic Preservation Office)
William Hernandez
Historic Preservation Specialist III
Department of Parks and Recreation
490 Chalan Palasyo
Agana Heights GU 96910

Guam Historic Resources Division
(Historic Preservation Office)
Alfred Masga
Archeologist Technician
Department of Parks and Recreation
490 Chalan Palasyo
Agana Heights GU 96910

Guam Homeland Security Department
Eric Fisher
Training and Exercise Coordinator
221-B Chalan Palasyo
Hagåtña GU 96910

Guam Homeland Security
Office of Civil Defense
Charles Ada
Director
221B Chalan Paliso
Agana Heights GU 96910

Guam Visitors Bureau
Gerry Perez
Executive Manager
401 Pale San Vitores Road
Tumon GU 96913

Guam Waterworks Authority
Heidi Ballendorf
Public Information Officer
578 North Marine Corps Drive
Tamuning GU 96913

Guam Waterworks Authority
David Craddick
General Manager
578 North Marine Corps Drive
Tamuning GU 96913

Port Authority of Guam
Joseph Duenas, Acting General Manager
1026 Cabras Highway, Suite 201
Piti GU 96915

Port Authority of Guam
Paul Shintaku, Department General Manager
1026 Cabras Hwy., Suite 201
Piti GU 96915

University of Guam
Harold Allen
President
303 University Station
Mangilao GU 96910

University of Guam Water and Environmental
Research Institute
Leroy Heitz
Director
WERI, University of Gaum, UOG Station
Mangilao GU 96913

University of Guam, Marine Laboratory
Barry Smith
Director
Marine Laboratory, University of Guam, UOG Station
Mangilao GU 96913

CNMI Coastal Resources Management Program
Joaquin D. Salas
Administrator
Box 10007 Second Floor Morgen Bldg.
San Jose, Saipan MP 96950

CNMI Department of Community and Cultural Affairs
Secretary
House #1341, Capitol Hill
Saipan MP 96950

CNMI Department of Community and Cultural
Affairs, Historic Preservation Office
Epifanio Cabrera
Director
House #1341, Capitol Hill
Saipan MP 96951

CNMI Department of Lands and Natural Resources
Ignacio Dela Cruz
Secretary
PO Box 10007
Saipan MP 96950

CNMI Department of Lands and Natural Resources
Soil and Water Conservation District
Manager
Caller Box 10007
Saipan MP 96950

CNMI Department of Lands and Natural Resources,
Division of Agriculture
Donald P. Flores, Director
Caller Box 10007
Saipan MP 96950

CNMI Department of Lands and Natural Resources,
Division of Fish and Wildlife
Sylvan O. Ifisomar
Director
PO Box 10007
Saipan MP 96950

CNMI Department of Lands and Natural Resources,
Division of Fish and Wildlife DFW Lower Base
Thomas Pangelinan
Secretary
Lower Base
Saipan MP 96949

CNMI Department of Lands and Natural Resources,
Division of Land Registration and Survey
Joaquin B. Songsong, Director
Caller Box 10007
Saipan MP 96950

CNMI Department of Lands and Natural Resources,
Division of Parks and Recreation
Antonio T. Benavente, Director
Caller Box 10007
Saipan MP 96950

CNMI Department of Public Safety
Tinian Fire Division
Director
Caller Box 10007
Saipan MP 96950

CNMI Division of Coastal Resources Management Office
John Starmer
Coral Reef Monitoring Biologist
P.O. Box 501304
Saipan MP 96950

CNMI Division of Coastal Resources Management Office
Kathy Yuknavage
Natural Resource Planner
P.O. Box 501304
Saipan MP 96950

CNMI Division of Environmental Quality
Brian Bearden
Environmental Engineer
P.O. Box 501304
Saipan MP 96950

CNMI Division of Environmental Quality
Fran Castro
Nonpoint Source and Marine Monitoring Program Manager
P.O. Box 501304
Saipan MP 96950

CNMI Division of Environmental Quality
Kate Fuller
Legal Counsel
P.O. Box 501304
Saipan MP 96950

CNMI Division of Environmental Quality
Peter Houk
Coral Reef Monitoring Biologist
P.O. Box 501304
Saipan MP 96950

CNMI Division of Environmental Quality
Frank Rabauliman
Director
P.O. Box 501304
Saipan MP 96950

CNMI Division of Fish & Wildlife
Richard B.
Seman
Director
P.O. Box 10007
Saipan MP 96950

CNMI Division of Fish & Wildlife
Mike Trianni
Fisheries Biologist
P.O. Box 501304
Saipan MP 96950

CNMI Division of Fish & Wildlife
Laura L. Williams
Wildlife Biologist / Botanist
P.O. Box 501304
Saipan MP 96950

CNMI Historic Preservation Office
Ronnie Rogers
Staff Archaeologist
P.O. Box 10007 Capital Hill
Saipan MP 96950

CNMI Northern Marianas College
Ag Research and Extension
Soil and Water Management Program
Craig Smith
Soil and Water Scientist--Saipan
Saipan MP 96950

CNMI Office of Military Liaison and Veterans Affairs
Frank Cepeda, Director
Juan S. Atalig Memorial Bldg. Isa Drive Capitol Hill
Caller Box 100007
Saipan MP 96950

Department of Community and Cultural Affairs
Daisy C. Villagomez-Bier
P.O. Box 5234
Saipan MP 96950

Department of Public Lands
Franz B. Reksid
P.O. Box 500380
Saipan MP 96950

Div. of Fish & Wildlife
Gayle Martin
Caller Box 10007
Saipan MP 96950

Marianas Public Lands Authority
John S. Del Rosario, Jr., Director
P.O. Box 500380
Saipan MP 96950

Marianas Visitors Authority
David M. Sablan, Board Chariman
P.O. Box 861
Saipan MP 96950

Office of the Commissioner
CNMI Department of Public Safety
Rebecca Warfield, Commissioner
Caller Box 10007
Saipan MP 96950

Office of the Secretary
CNMI Department of Community and Cultural Affairs
Daisy Villagomez-Bier, Secretary
House #1341, Capitol Hill
Saipan MP 96950

Elected Officials

Congressional Delegate Guam District Office
Honorable Madeline Z. Bordallo
Congresswoman
120 Father Duenas Ave., Suite 107
Hagåtña GU 96910

Congressional Delegate Washington D.C. Office
Honorable Madeline Z. Bordallo
Congresswoman
427 Cannon HOB
Washington DC 25015-5301

Federated States of Micronesia, Department of Foreign Affairs
Hon. Mr. Lorin Robert
Secretary of Foreign Affairs
PS123, Palikir
Pohnpei State FM 96941

Federated States of Micronesia, Office of the President
H.E. Mr. Emanuel Mori
President
PS53, Palikir
Pohnpei State FM 96941

30th Guam Legislature
Honorable Frank Blas
Senator
155 Hessler Place
Hagåtña GU 96910

30th Guam Legislature
Honorable James Espaldon
Senator
Sinajana Shopping Mall; Ste 16B777 Rte 4
Sinajana GU 96926

30th Guam Legislature
Honorable Mark Forbes
Speaker
155 Hesler Place, Lehislaturan Guåhan
Hagåtña GU 96910

30th Guam Legislature
Honorable Judith Guthertz
Senator
155 Hessler Place
Hagåtña GU 96910

30th Guam Legislature
Honorable Frank Ishizaki
Senator
155 Hessler Place
Hagåtña GU 96910

30th Guam Legislature
Honorable Edward J.B. Calvo
Vice Speaker
155 Hessler Place
Hagåtña GU 96910

30th Guam Legislature
Honorable Jesse Lujan
Senator
655 S Marine Corps Dr; Ste 100
Tamuning GU 96913

30th Guam Legislature
Honorable Tina Rose Muna-Barnes
Senator
155 Hessler Place
Sinajana GU 92926

30th Guam Legislature
Honorable Adolpho Palacios
Senator
155 Hessler Place
Hagåtña GU 92910

30th Guam Legislature
Honorable Vincent Pangelinan
Senator
155 Hessler Place
Hagåtña GU 92910

30th Guam Legislature
Honorable Rory J. Respicio
Senator
155 Hessler Place
Hagåtña GU 92910

30th Guam Legislature
Honorable David Shimzu
Senator
155 Hessler Place
Hagåtña GU 96910

30th Guam Legislature
Honorable Ray Tenorio
Senator
167 Marine Drive, Suite 104
Hagåtña GU 96932

30th Guam Legislature
Honorable Judith Won Pat
Senator
155 Hessler Place
Hagåtña GU 96910

30th Guam Legislature
Honorable Benjamin JF Cruz
Senator
155 Hessler Place
Hagåtña GU 96910

Guam Committee on Tourism, Maritime, Military & Veterans Affairs
Honorable Antonio Unipingco
Chairman
155 Hessler Place
Hagåtña GU 96910

Mayors' Council of Guam
Mr. John F. Blas
Executive Director
P.O. Box 786
Hagåtña GU 96932

Office of the Governor
Governor Felix Perez Camacho
Governor
P.O. Box 2950
Hagåtña GU 96932

Office of the Governor
Lt. Governor Michael W. Cruz
P.O. Box 2950
Hagåtña GU 96932

Village of Agana Heights
Mayor Paul McDonald
PO Box 786
Hagåtña GU 96932

Village of Agat
Mayor Carol Tayama
PO Box 786
Hagåtña GU 96932

Village of Asan-Maina
Mayor Vincente San Nicolas
PO Box 786
Hagåtña GU 96932

Village of Barrigada
Mayor Jessie Palican
PO Box 786
Hagåtña GU 96932

Village of Chalan Pago/Ordot
Mayor Jessy Gogue
PO Box 786
Hagåtña GU 96932

Village of Dededo
Mayor Melissa Savares
PO Box 786
Hagåtña GU 96932

Village of Hagåtña
Mayor John Cruz
PO Box 786
Hagåtña GU 96932

Village of Inarajan
Mayor Franklin Taitague
PO Box 786
Hagåtña GU 96932

Village of Mangilao
Mayor Nonita Blas
PO Box 786
Hagåtña GU 96932

Village of Merizo
Mayor Ernest Chargualaf
PO Box 786
Hagåtña GU 96932

Village of Mongmong-Toto-Maite
Mayor Andrew Villagomez
PO Box 786
Hagåtña GU 96932

Village of Piti
Mayor Vicente Gumataotao
PO Box 786
Hagåtña GU 96932

Village of Santa Rita
Mayor Dale Alvarez
P.O. Box 766
Hagåtña GU 96932

Village of Sinajana
Mayor Roke Blas
PO Box 786
Hagåtña GU 96932

Village of Talofofo
Mayor Vincente Taitague
PO Box 786
Hagåtña GU 96932

Village of Tamuning-Tumon-Harmon
Mayor Francisco C Blas
PO Box 786
Hagåtña GU 96932

Village of Umatac
Mayor Daniel Sanchez
PO Box 786
Hagåtña GU 96932

Village of Yigo
Mayor Robert Lizama
PO Box 786
Hagåtña GU 96932

Village of Yona
Mayor Jose Terlaje
PO Box 786
Hagåtña GU 96932

Village of Rota
Mayor Benjamin Manglona
PO Box 537
Rota MP 96951

CNMI House of Representatives
Honorable Joseph Camacho
Floor Leader
P.O. Box 500586
Saipan MP 96950

CNMI House of Representatives
Honorable Edwin Aldan
Representative
P.O. Box 500586
Saipan MP 96950

CNMI House of Representatives
Honorable Arnold I Palacios
Speaker
P.O. Box 500586
Saipan MP 96950

CNMI House of Representatives
Honorable David M Apatang
Representative
P.O. Box 500586
Saipan MP 96950

CNMI House of Representatives
Honorable Diego Benavente
Representative
P.O. Box 500586
Saipan MP 96950

CNMI House of Representatives
Honorable Joseph P. Deleon Guerro
Vice Speaker
P.O. Box 500586
Saipan MP 96950

CNMI House of Representatives
Honorable Joseph C Reyes
Representative
P.O. Box 500586
Saipan MP 96950

CNMI House of Representatives
Honorable Christina M Sablan
Representative
P.O. Box 500586
Saipan MP 96950

CNMI House of Representatives
Honorable Ralph DLG Torres
Representative
P.O. Box 500586
Saipan MP 96950

CNMI House of Representatives
Honorable Oscar M Babauta
Representative
P.O. Box 500586
Saipan MP 96950

CNMI House of Representatives
Honorable Raymond D Palacios
Representative
P.O. Box 500586
Saipan MP 96950

CNMI House of Representatives
Honorable Francisco Dela Cruz
Representative
P.O. Box 500586
Saipan MP 96950

CNMI House of Representatives
Honorable Heinz S Hofschneider
Representative
P.O. Box 500586
Saipan MP 96950

CNMI House of Representatives
Honorable Ramon A. Tebuteb
Representative
P.O. Box 500586
Saipan MP 96950

CNMI House of Representatives
Honorable Edward T Salas
Representative
P.O. Box 500586
Saipan MP 96950

CNMI House of Representatives
Honorable Stanely T. McGinnis Torres
Representative
P.O. Box 500586
Saipan MP 96950

CNMI House of Representatives
Honorable Justo S. Quitugua
Representative
P.O. Box 500586
Saipan MP 96950

CNMI House of Representatives
Honorable Rosemond B Santos
Representative
P.O. Box 500586
Saipan MP 96950

CNMI House of Representatives
Honorable Ray N. Yumul
Representative
P.O. Box 500586
Saipan MP 96950

CNMI House of Representatives
Honorable Victor B Hocog
Representative
P.O. Box 500586
Saipan MP 96950

CNMI Public Information and Protocol Office
Mr. Charles P. Reyes, Jr.
Press Secretary
Caller Box 10007 - Capital Hill
Saipan MP 96950

CNMI Senate
Honorable Luis Crisostimo
Senator
PO Box 500129
Saipan MP 96950

CNMI Senate
Honorable Paterno Hocog
Senator
PO Box 500129
Saipan MP 96950

CNMI Senate
Honorable Jude Hofschneider
Senator
PO Box 500129
Saipan MP 96950

CNMI Senate
Honorable Paul Manglona
Senator
PO Box 500129
Saipan MP 96950

Office of the Governor
Ms. Catherine Perry Anderson
Caller Box 10007 - Capital Hill
Saipan MP 96950

Office of the Mayor of Northern Islands
Mayor Valentino Taisacan
YMCA Bldg; PO Box 2859
Saipan MP 96950

CNMI Senate
Honorable Felix Mendiola
Senator
PO Box 500129
Saipan MP 96950

CNMI Senate
Honorable Joseph Mendiola
Senate President Pro tempore
PO Box 500129
Saipan MP 96950

CNMI Senate
Honorable Maria Pangelinan
Senator
PO Box 500129
Saipan MP 96950

CNMI Senate
Honorable Pete Reyes
Senator
PO Box 500129
Saipan MP 96950

CNMI Senate
Honorable Henry San Nicolas
Senator
PO Box 500129
Saipan MP 96950

CNMI, Office of the Mayor, Municipality of Saipan
Mayor Juan Tudela
PO Box 501457
Saipan MP 96950

Commonwealth of the Northerm Mariana Islands
Governor Benigno Repeki
Fitial Governor
Juan S. Atalig Memorial Building Isa Drive
Capitol Hill Caller Box 10007
Saipan MP 96950

Commonwealth of the Northerm Mariana Islands
Lt. Governor Timothy Villagomez
Juan S. Atalig Memorial Building Isa Drive
Capitol Hill Caller Box 10007
Saipan MP 96950

U.S. House of Representatives
Representative Pedro Tenorio
CNMI Resident Representative
1345 Ascension Ct., P.O. Box 504959
Saipan MP 96950

Office of the Mayor of Tinian
Mayor Francisco M Borja
P.O. Box 59
Tinian MP 96952

Non-governmental Organizations

Chamorro Collective
Jonathan B. Diaz
477 Jean St., Apt. A
Oakland CA 94610

Commission on Decolonization
Eddie Benavente, Executive Director
P.O. Box 2950
Hagatna GU 96932

Coral Reef Marine Center
Manager
167H Calvo Industrial Park
Tamuning GU 96911

Earth Justice
Director
223 South King Street, Suite 400
Honolulu HI 96813

Earth Justice National Headquarters
Director
426 17th Street, 6th Floor
Oakland CA 94612-2820

Fleet Reserve Association
Director
National Headquarters 125 N. West Street
Alexandria VA 22314-2754

Governor's Civilian-Military Taskforce
Donald Goldhorn, Adjuntant General
430 Route 16 Bldg. 300 Rm 113
Barrigada GU 96913

Guam Contractor's Association
James A. Martinez, Executive Director
719 N. Marine Drive, Suite 203
East West Business Center
Upper Tumon GU 96913

Guam Diving Industry Association (GIDA)
John Bent , President
275 C Farenholt Ave. Suite 163
Tamuning GU 96931

Guam Fisherman's Co-op
Mike Duenas, General Manager
Greg D. Perez Marina
Hagatna GU 96910

I Nasion Chamorro
Ben Garrido
Maga Haga
PO Box 6132
Merizo GU 96916

International Association of Fish & Wildlife Agencies
Edward Parker, President
444 North Capitol Street, NW, Suite 725
Washington DC 20001

Mariana Islands Nature Alliance
Kathy Yuknavage
P.O. Box 506645
Saipan MP 96950

Micronesia Youth Service Network
Sarah Nededos
406 Mai Mai Rd.
Chalan Pago GU 96910

Micronesian Diving Association (MDA)
Pete Peterson, General Manager
856 N. Marine Dr.
Piti GU 96915

Natural Resource Defense Council
Joel Reynolds, Senior Attorney
1314 Second Street
Santa Monica CA 90401

Natural Resources Defense Council
Regional Office
111 Sutter St., 20th Floor
San Francisco CA 94104

Navy League
Director
National Headquarters 2300 Wilson Blvd., Suite 200
Arlington VA 22201-3308

Pacific Concerns Resource Center
Director
Private Mail Bag
Suva Fiji Islands

Rotary Club of Guam
Dianne Keller
President
Attn: Rotary Club of Guam, 202 Hilton Road
Tumon Bay GU 96913

Rotary Club of Northern Guam
Steffen Niu
President
R.I. District 2750 P.O. Box 21542
GMF GU 96921

Sierra Club
Director
85 Second Street, 2nd Floor
San Francisco CA 94105

The Nature Conservancy, FSM Program Office
Trina Leberer
Executive Director
P.O. Box 216 Kolonia
Pohnpei FSM 96941

The Nature Conservancy, Micronesia Program
Trina Leberer
Executive Director
P.O. Box 5411
Hagatna GU 96932

Veterans of Foreign Wars
Director
National Headquarters 406 West 34th Street
Kansas City MO 64111

Women's Working Group
c/o Senator Won Pat's Office
Director
Payless Corporate Office Bldg. 116 Chalan Santo Papa
Hagatna GU 96910

Community and Business Organizations

A.B. Won Pat International Airport, Guam
Jess Q. Torres, Executive Manager
355 Chalan Pasaheru
Tamuning GU 96913

Alupang Beach Club Inc, (Parasailing Operation)
Kazu Aoki, General Manager
997A Marine Dr.
Tamuning GU 96931

Aqua World Marina
Bree McDowell, General Manager
198 Adrian Sanchez St
Harmon GU 96913

Atlantis Submarines
Bo Baba, General Manager
756 S. Marine Corps Dr. Suite 201
Tamuning GU 96913

Bailan Tasi Windsurfing
Cathy Moore-Linn, President
P.O. Box 3643
Hagåtña GU 96911

Cabras Marine Corp. (Commercial Harbor Pilots)
Director
1026 Cabras Hwy, Suite 114
Piti GU 96915

Guam Chamber of Commerce
Reina A. Leddy, President
173 Aspinall Avenue, Suite 101, Ada Plaza Center
Hagåtña GU 96910

Guam Contractors Association
James Martinex, Executive Director
718 N. Marine Corps Dr., Suite 203, East-West Business Center
Upper Tumon GU 96913

Guam Lagoon Scuba Diving
Booken Oh, Manager
PO Box 23983
Barrigada GU 96921

Guam Sailing Federation
Victor Torres, President
P.O. Box 3643
Hagåtña GU 96932

Guam Tropical Dive Station (GTDS)
Paula Bent, General Manager
P.O. Box 1649
Hagåtña GU 96932

Isla Jetski Club
Manager
201 A Trankilo St.
Tamuning GU 96931

Marianas Yacht Club
Cindy Bell, Commodore
P.O. Box 3643
Hagåtña GU 96911

Ocean Jet Club
Keiko Tran, Manager
Marine Dr.
Hagåtña GU 96932

Real World Diving
Bob O'dell, Manager
315 Marina Road
Piti GU 96925

Scuba Company
Rick Tuncap, President
PO Box 11901
Tamuning GU 96931

CNMI Department of Lands and Natural Resources
Tinian Farmers and Fishermans' Market
Market Manager
Caller Box 10007
Saipan MP 96950

Saipan Chamber of Commerce
Board of Directors
P.O. Box 500806 CK
Saipan MP 96950

Saipan Chamber of Commerce
Jim Arenovski, President
P.O. Box 500806 CK
Saipan MP 96950

Helber Hastert & Fee
Faith Caplan
733 Bishop St, Suite 2590
Honolulu HI 96813

Honolulu Japanese Chamber of Commerce
Director
1132 Bishop Street, Suite 402
Honolulu HI 96826

Japanese Chamber of Commerce &
Industry of Hawaii
Director
2454 South Beretania Street, Suite 201
Honolulu HI 96826

Okinawan Chamber of Commerce of
Hawaii aka WUB Hawaii
Director
2454 S. Berentania St., Ste. 201
Honolulu HI 96825

The Chamber of Commerce of Hawaii
Director
400 Hualani St., Ste. 20B
Honolulu HI 96813

Media

Marianas Business Journal
Jay Baza Pascua, Editor
P.O. Box 3191
Hagåtña GU 96932

Marianas Variety Guam
Amier Younis, Editor
215 Rojas St., Ste. 101
Harmon GU 96913

Pacific Daily News
Gaynor Daleno
Business Editor
P.O. Box DN
Hagåtña GU 96932

Pacific Daly News, Guam Publications Inc.
Lee Webber, Publisher
P.O. Box DN
Hagåtña GU 96910

Marianas Variety
Zaldy Dandan, Editor
P.O. Box 231
Saipan MP 96950

Saipan Tribune
Marconi Calindas, Reporter
PMB 34 Box 1001
Saipan MP 96950

Associated Press
Dave Briscoe, Bureau Chief
500 Ala Moana Blvd. #590
Honolulu HI 96813

Hawaii Tribune Herald
David Bock, Editor
P.O. Box 767
Hilo HI 96721

Honolulu Advertiser
Fernando Pizarro, City Editor
605 Kapiolani Blvd.
Honolulu HI 96813

Honolulu Star-Bulletin
Ed Lynch, City Editor
7 Waterfront Plaza, 500 Ala Moana Blvd. Suite 500
Honolulu HI 96813

Maui News
David Hoff, Editor
100 Mahalani Street
Wailuku HI 96793

Pacific Business News
Jim Kelly, Editor
1833 Kalakaua Ave.
Honolulu HI 96815

Isla 61 and Classic 94 FM
Micronesian Broadcasting Corp.
Joseph Calvo, General Manager
P.O. Box 368
Hagåtña GU 96910

KOKU FM, Western Systems Inc.
Roland Franquez, General Manager
530 West O'Brien Dr.
Hagåtña GU 96910

Newstalk 57AM, Sorenson Pacific Broadcasting Inc.
Patti Arroyo
News Director
P.O. Box GM
Hagåtña GU 96910

IBB Voice of America Tinian
Director
330 Independence Ave
Washington DC 20237

Information Repositories

University of Guam Robert F. Kennedy Memorial Library, Government Documents
Suzanne Bell
Librarian
Tan Siu Lin Building, UOG Station
Mangilao GU 96923

Rota Public Library
c/o Mayor Joseph S. Inos
Village of Rota
P.O. Box 537
Rota, MP 96951

Joeten-Kiyu Public Library
Kevin Latham
State Library Director
P.O. Box 501092
Saipan MP 96950

Northern Marianas College Public Library
Librarian
P.O. Box 459
Tinian MP 96952

Individuals

Aguilar, Margaret
Dedido, GU

Aloaig-Leon Guerrero, Machelle
Hagatna, GU

Anderson, Jon A.
Saipan, MP

Aniti, Maya
Mangilao, GU

Aranza, Ed
GMF, Barrigada, GU

Bearden, Brian
Saipan, MP

Benavent, Robert L.G.
Hagatna, GU

Benavente, Eddie
Hagatna, GU

Bilmemghan-Balanti, Sami
Saipan, MP

Blackburn, Mark
Saipan, MP

Bordallo, Miguel
Hagatna, GU

Borja, Vicente H.
Tinian, MP

Borja, Nazarid
Tinian, MP

Brewster, Larry
Tinian, MP

Brown, Val
Mangilao, GU

Caras, Gemma
Saipan, MP

Caresoy, Bernadette
Tinian, MP

Charfaures, Joey C.
Tinian, MP

Coleman, Ruth
Saipan, MP

Creachbaum, Sarah
Hagatna, GU

Dell'Isola, Elaine
Hagatna, GU

Denney, Peggy
Barrigada, GU

Donato, Agnes E.
Saipan, MP

Ebmeus, Moises
Tinian, MP

El-Rali, Michel
Saipan, MP

Fejeron, Tom
Barrigada, GU

Fleming, Zania
Tinian, MP

Franquez, R.
Hagatna, GU

Gamatrotao, Bea
Hagatna, GU

Guerrero, Robert
Saipan, MP

Hechanova, Thelma
Hagatna, GU

Hernandez, Jacq
Saipan, MP

Hocoy, Lary
Saipan, MP

Hoftclmeina, Ed
Tinian, MP

Jackson, Danny
Barrigada, GU

Jackson, Josephine
Barrigada, GU

Jackson, Kili
Tinian, MP

Johnson, Nathan
Hagatna, GU

Joyner, John B.
Saipan, MP

Kaipat, Cinta
Saipan, MP

Kaipat, Gus
Saipan, MP

Kalojian, Harout
Saipan, MP

King, Vince
Tinian, MP

Kuy, Ta Bun
Saipan, MP

Leberer, Trina
Hagatna, GU

Leon Guerrero, Carlotta
Hagatna, GU

Liu, Tom
Tinian, MP

Loan, David
Saipan, MP

Lya, Evangeline
Hagatna, GU

Malore, Mike
Saipan, MP

McKagan, Steve
Saipan, MP

Mendiola, Joe
Tinian, MP

Mendiola-Long, Phillip
Tinian, MP

Olopai, Linto M.
Saipan, MP

Pangelinan, Manny
Saipan, MP

Paulino, Herman
Santa Rita, GU

Penaranda, Mark
Saipan, MP

Perez, Jose S.
Tamuning, GU

Quicheche, Ray
Saipan, MP

Quinata, Debbie
Merizo, GU

Rabauliman, Amada
Saipan, MP

Reyes, Antonio L.G.
Saipan, MP

Roberto, J. Peter
Hagatna, GU

Roberto, Phil
Hagatna, GU

Sablan, Antonio
Sinajana, GU

Sablan, Patria U.
Sinajana, GU

Sablow, Roy
Saipan, MP

Sager, Randy G.
Tamuning, GU

Santos, Eugene
Hagatna, GU

Sarden, Rogelio A.
Tamuning, GU

Satallg, Joagui
Saipan, MP

Scott, John
Yona, GU

Sirok, Jim
Saipan, MP

Skvaril, Cerila P.
Nimitz Hill, GU

Smith, Ron
Saipan, MP

Taitingfong, AbuRose
Barrigada, GU

Tighe, Ruth
Saipan, MP

Torres, Trini
Barrigada, GU

Torres, Victor R.
Hagatna, GU

Trianni, Mike
Saipan, MP

Villagomez, Angelo
Saipan, MP

Villazon, Alex
Saipan, MP

Waki, Absalon
Saipan, MP

Wedding, James M.
Tinian, MP

Wyttenbach-Santos, Richard
Mangilao, GU

Youns, Pg
Saipan, MP

Yus, Alfred
Tinian, MP

Zak, Paul
Saipan, MP

Zotomayou, Alexie
Saipan, MP

This page intentionally left blank.

APPENDIX A

COOPERATING AGENCY REQUESTS AND ACCEPTANCE LETTERS

This Page Intentionally Left Blank

COOPERATING AGENCY REQUESTS

1. Dr. William T. Hogarth
   Assistant Administrator
   National Oceanic and Atmospheric Administration (NOAA) Fisheries
   1315 East West Highway
   Silver Spring, MD 20910

2. Mr. Dirk Kempthorne
   Secretary of the Interior
   Department of the Interior
   1849 C Street, NW
   Washington, DC 20240

3. Mr. Mike Johanns
   Secretary of Agriculture
   U.S. Department of Agriculture
   Animal and Plant Health Inspection Services
   Wildlife Services
   1400 Independence Avenue, S.W.
   Washington, DC 20250

4. Marion C. Blakey
   Administrator, Federal Aviation Administration
   800 Independence Ave., SW
   Washington, DC 20591

5. Commander, 196th Infantry Brigade
   Headquarters Bldg 525
   Fort Shafter, HI 96858-5300

6. Commander, Marine Corps Bases Pacific
   Marine Corps Bases Hawaii
   P.O. Box 64119
   Camp H.M. Smith, HI 96861-4119

7. Mr. Kevin Billings
   Deputy Assistant Secretary
   (Environment, Safety and Occupational Health)
   HQ SAF/IEE
   1665 Air Force Pentagon
   Washington, DC 20330-1665

8. Commander, U.S. Coast Guard Sector Guam
   PSC 455 Box 176
   FPO AP 96540-1056

9. Commanding General
   U.S. Army Reserve
   9th Regional Readiness Command
   1557 Pass Street
   Fort Shafter Flats
   Honolulu, Hawaii 96819

10. Adjutant General
    Guam National Guard
    430 Army Drive Bld 300, Rm 113
    Barrigada, Guam 96913-4421

This Page Intentionally Left Blank

DEPARTMENT OF THE NAVY
OFFICE OF THE CHIEF OF NAVAL OPERATIONS
2000 NAVY PENTAGON
WASHINGTON, DC 20350-2000

IN REPLY REFER TO

5090
Ser N456E/7U158221
9 Aug 2007

Dr. William T. Hogarth
Assistant Administrator
National Oceanic and Atmospheric
Administration (NOAA) Fisheries
1315 East West Highway
Silver Spring, MD 20910

Dear Dr. Hogarth:

In accordance with the National Environmental Policy Act (NEPA) and Executive Order 12114, the Department of the Navy (Navy), as executive agent for the Department of Defense (DoD), is preparing an Environmental Impact Statement/ Overseas Environmental Impact Statement (EIS/OEIS) to evaluate potential environmental effects of using the Mariana Islands Range Complex (MIRC) to achieve and maintain military readiness and to support and conduct current, emerging, and future training activities and research, development, test, and evaluation (RDT&E) events.

In order to adequately evaluate the potential environmental effects of the Proposed Action, Navy and the National Marine Fisheries Service would need to work together on acoustic effects to marine species protected under the Marine Mammal Protection Act (MMPA) and the Endangered Species Act. To assist in this effort and in accordance with 40 CFR Part 1501 and the Council on Environmental Quality Cooperating Agency guidance issued on January 30, 2002, Navy requests NMFS serve as a cooperating agency for the development of the MIRC EIS/OEIS.

The MIRC consists of multiple ranges and training areas of land, sea space (nearshore and offshore), undersea space, and air space under different controlling authorities in the Territory of Guam, the Commonwealth of the Northern Mariana Islands, and surrounding waters. The Proposed Action for the MIRC EIS/OEIS is to:

- Maintain baseline operations at current levels;

- Increase training operations from current levels as necessary to support Military Service training requirements;

- Implement new and enhanced range complex capabilities;

- Increase and accommodate planned RDT&E events.

The Proposed Action will further our statutory obligations under Title 10 of the United States Code to provide combat capable forces ready to deploy worldwide.

The No Action Alternative is the continuation of training activities and major range events in the MIRC at current levels. Two action alternatives are proposed to accomplish the Proposed Action. Alternative 1 consists of an increase in the number of training activities, from levels described in the No Action Alternative, along with upgrades to ranges and training areas. Alternative 2 consists of all elements of Alternative 1 with an additional increase in the number and types of training operations and implementation of range enhancements including a fixed underwater training range.

The EIS/OEIS will address measurably foreseeable activities in the particular geographical areas affected by the No Action Alternative and action alternatives. This EIS/OEIS will analyze the effects of sound in the water on marine mammals in the areas where MIRC activities occur. In addition, other environmental resource areas that will be addressed as applicable in the EIS/OEIS include: air quality; airspace; biological resources, including threatened and endangered species; cultural resources; hazardous materials and waste; health and safety; land use; noise; socioeconomics; transportation; and water resources.

As executive agent for the lead agency, DoD, the Navy will be responsible for overseeing preparation of the EIS/OEIS that includes but is not limited to the following:

- Gathering all necessary background information and preparing the EIS/OEIS and all necessary permit applications associated with acoustic issues on the underwater ranges.

- Working with NMFS personnel to determine the method of estimating potential effects to protected marine species, including threatened and endangered species.

- Determining the scope of the EIS/OEIS, including the alternatives evaluated.

- Circulating the appropriate NEPA documentation to the general public and any other interested parties.

- Scheduling and supervising meetings held in support of the NEPA process, and compiling any comments received.

- Maintaining an administrative record and responding to any Freedom of Information Act requests relating to the EIS/OEIS.

As a cooperating agency, the Navy requests NMFS support the Navy in the following manner:

- Provide timely comments after the Agency Information Meeting (which will be held at the onset of the EIS/OEIS process) and on working drafts of the EIS/OEIS documents. The Navy requests that comments on draft EIS/OEIS documents be provided within 21 calendar days.

- Respond to Navy requests for information. Timely NMFS input will be critical to ensure a successful NEPA process.

- Coordinate, to the maximum extent practicable, any public comment periods that is necessary in the MMPA permitting process with the Navy's NEPA public comment periods.

- Participate, as necessary, in meetings hosted by the Navy for discussion of EIS/OEIS related issues.

- Adhere to the overall project schedule as agreed upon by the Navy and NMFS.

- Provide a formal, written response to this request.

The Navy views this agreement as important to the successful completion of the NEPA process for the Mariana Island Range Complex EIS/OEIS. It is Navy's goal to complete the analysis as expeditiously as possible, while using the best scientific information available. NMFS assistance will be invaluable in this endeavor.

My point of contact for this action is Ms. Karen M. Foskey, (703) 602-2859, email:Karen.Foskey@navy.mil.

Sincerely,

WILLIAM G. MATTHEIS
Acting Director, Environmental
Readiness Division (OPNAV N45)

Copy to:
DASN (Environment)
OAGC (I&E)
PACOM (J44)
US Naval Forces Marianas
CPF (N01CE, N7)
COMNAVFACENGCOM, Marianas

DEPARTMENT OF THE NAVY
U.S. DEFENSE REPRESENTATIVE GUAM/ COMMONWEALTH OF THE NORTHERN MARIANA ISLANDS/
FEDERATED STATES OF MICRONESIA/ REPUBLIC OF PALAU
PSC 455 BOX 152
FPO AP 96540-1000

IN REPLY REFER TO:

3500
Ser N00/ 0260
September 6, 2007

CERTIFIED MAIL – RETURN RECEIPT REQUESTED

Mr. Dirk Kempthorne
Secretary of the Interior
Department of the Interior
1849 C Street, NW
Washington, DC 20240

Dear Mr. Dirk Kempthorne:

SUBJECT: MARIANA ISLANDS RANGE COMPLEX ENVIRONMENTAL IMPACT STATEMENT – COOPERATING AGENCY

The U.S. Department of Defense (DoD) has initiated an Environmental Impact Statement (EIS) to address the potential environmental impacts of proposed military training, research and development, and testing within the Mariana Islands Range Complex (MIRC). As an update to the 1999 EIS for Military Training in the Marianas, the MIRC EIS will analyze military training activities throughout Guam and the Commonwealth of Northern Mariana Islands (CNMI). The Commander, U.S. Pacific Fleet (COMPACFLT), on behalf of the Department of the Navy, will act as Executive Agent for DoD in completing this EIS. DoD requests your participation in this EIS as a cooperating agency pursuant to the National Environmental Policy Act and associated regulations.

DoD will study the environmental effects of increasing usage and enhancing the capability of the MIRC to achieve and maintain military readiness across all Service components, and to conduct current, emerging, and future training and research, development, testing, and evaluation (RDT&E) operations. The No-Action Alternative is the continuation of the current volume and types of training, RDT&E activities, and base operations that was approved in the 1999 EIS for Military Training in the Marianas. This includes all multi-Service training activities and operations on military ranges and training areas including: Andersen Air Force Base (Main Base, Northwest Field, Andersen South, and Tarague Beach); Commander, U.S. Naval Forces Marianas and its off-shore areas; Farallon de Medinilla; Tinian; Saipan; Rota; and Air Traffic Control Assigned Airspace.

Two action alternatives are proposed. Alternative 1 includes the activities described in the No-Action Alternative with the addition of an increase in current training operations on existing ranges and training areas to support military units located either permanently or temporarily in DoD Area of Responsibility (AOR). Alternative 2 would include all the operations described in Alternative 1 with the addition of new types of operations on existing ranges and training areas

and adjacent air and ocean areas. A complete description of the alternatives will be provided in the Description of Proposed Action and Alternatives, which is currently being completed.

In order to adequately evaluate the potential environmental effects of this proposed action, DoD and the Department of the Interior need to work together in assessing potential impacts to training activities and operations within the joint MIRC study area. It is DoD's desire to formalize this relationship as outlined in CEQ guidelines (40 CFR Part 1501.6).

As defined in 40 CFR 1501.6, DoD is the lead agency for the MIRC EIS. The MIRC EIS is funded through the Navy's Tactical Training Theater Assessment and Planning (TAP) program. COMPACFLT will process the MIRC EIS in accordance with other TAP documents to ensure consistency. The Chief of Navy Operations and the Assistant Secretary of the Navy (Installations and Environment) will provide concurrence prior to public release of the draft and final documents. DoD is requesting that the Department of the Interior be a cooperating agency as defined in 40 CFR 1501.6.

Per 40 CFR 1501.6 DoD as the lead agency shall:

1. Request the participation of each cooperating agency in the NEPA process at the earliest possible time.
2. Use the environmental analysis and proposals of cooperating agencies with jurisdiction by law or special expertise, to the maximum extent possible consistent with its responsibility as lead agency.
3. Meet with a cooperating agency at the latter's request.

Each cooperating agency shall:

1. Participate in the NEPA process at the earliest possible time.
2. Participate in the scoping process.
3. Assume, on request of the lead agency, responsibility for developing information and preparing environmental analyses, including portions of the environmental impact statement for which the cooperating agency has special expertise.
4. Make available staff support at the lead agency's request to enhance the latter's interdisciplinary capability.
5. Use their own funds.

DoD views this agreement as important to the successful completion of the NEPA process for the MIRC EIS. DoD's goal is to complete the analysis as expeditiously as possible, while using the best scientific information available. The Draft EIS is scheduled for public review in February 2009 with the Final EIS released in October 2009, and the Record of Decision for this EIS published in December 2009. Your assistance will be invaluable in that endeavor.

3500
Ser N00/ 0260
September 6, 2007

We appreciate your consideration of our request and look forward to your response. Should you have any questions or need additional information, please contact Mr. Neil Sheehan, COMPACFLT N01CE13, at (808) 474-7836, or by email at neil.a.sheehan.ctr@navy.mil.

Sincerely,

W. D. FRENCH
Rear Admiral, U.S. Navy

Copy to:
Assistant Secretary of the Navy (Installations & Environment)
Deputy Assistant Secretary of the Navy (Installations & Environment)
Office of Assistant General Council (Installations & Environment)
Commander, Navy Installations Command
Commander, Pacific Fleet N01CE
Commander, Pacific Fleet N7 (Mr. Long)
Naval Facilities Engineering Command, Pacific (Environmental)
Naval Facilities Engineering Command, Marianas (Environmental)

DEPARTMENT OF THE NAVY
U.S. DEFENSE REPRESENTATIVE GUAM/ COMMONWEALTH OF THE NORTHERN MARIANA ISLANDS/
FEDERATED STATES OF MICRONESIA/ REPUBLIC OF PALAU
PSC 455 BOX 152
FPO AP 96540-1000

IN REPLY REFER TO:

3500
Ser N00/ 0254
September 6, 2007

CERTIFIED MAIL – RETURN RECEIPT REQUESTED

Mr. Mike Johanns
Secretary of Agriculture
U.S. Department of Agriculture
Animal and Plant Health Inspection Services
Wildlife Services
1400 Independence Avenue, S.W.
Washington, DC 20250

Dear Mr. Mike Johanns:

SUBJECT: MARIANA ISLANDS RANGE COMPLEX ENVIRONMENTAL IMPACT STATEMENT – COOPERATING AGENCY

The U.S. Department of Defense (DoD) has initiated an Environmental Impact Statement (EIS) to address the potential environmental impacts of proposed military training, research and development, and testing within the Mariana Islands Range Complex (MIRC). As an update to the 1999 EIS for Military Training in the Marianas, the MIRC EIS will analyze military training activities throughout Guam and the Commonwealth of Northern Mariana Islands (CNMI). The Commander, U.S. Pacific Fleet (COMPACFLT), on behalf of the Department of the Navy, will act as Executive Agent for DoD in completing this EIS. DoD requests your participation in this EIS as a cooperating agency pursuant to the National Environmental Policy Act and associated regulations.

DoD will study the environmental effects of increasing usage and enhancing the capability of the MIRC to achieve and maintain military readiness across all Service components, and to conduct current, emerging, and future training and research, development, testing, and evaluation (RDT&E) operations. The No-Action Alternative is the continuation of the current volume and types of training, RDT&E activities, and base operations that was approved in the 1999 EIS for Military Training in the Marianas. This includes all multi-Service training activities and operations on military ranges and training areas including: Andersen Air Force Base (Main Base, Northwest Field, Andersen South, and Tarague Beach); Commander, U.S. Naval Forces Marianas, and its off-shore areas; Farallon de Medinilla; Tinian; Saipan; Rota; and Air Traffic Control Assigned Airspace.

Two action alternatives are proposed. Alternative 1 includes the activities described in the No-Action Alternative with the addition of an increase in current training operations on existing ranges and training areas to support military units located either permanently or temporarily in

DoD Area of Responsibility (AOR). Alternative 2 would include all the operations described in alternative 1 with the addition of new types of operations on existing ranges and training areas and adjacent air and ocean areas. A complete description of the alternatives will be provided in the Description of Proposed Action and Alternatives, which is currently being completed.

In order to adequately evaluate the potential environmental effects of this proposed action, DoD and the U.S. Department of Agriculture need to work together in assessing potential impacts to training activities and operations within the joint MIRC study area. It is DoD's desire to formalize this relationship as outlined in CEQ guidelines (40 CFR Part 1501.6).

As defined in 40 CFR 1501.6, DoD is the lead agency for the MIRC EIS. The MIRC EIS is funded through the Navy's Tactical Training Theater Assessment and Planning (TAP) program. COMPACFLT will process the MIRC EIS in accordance with other TAP documents to ensure consistency. The Chief of Navy Operations and the Assistant Secretary of the Navy (Installations and Environment) will provide concurrence prior to public release of the draft and final documents. DoD is requesting that the U.S. Department of Agriculture be a cooperating agency as defined in 40 CFR 1501.6.

Per 40 CFR 1501.6 DoD as the lead agency shall:

1. Request the participation of each cooperating agency in the NEPA process at the earliest possible time.
2. Use the environmental analysis and proposals of cooperating agencies with jurisdiction by law or special expertise, to the maximum extent possible consistent with its responsibility as lead agency.
3. Meet with a cooperating agency at the latter's request.

Each cooperating agency shall:

1. Participate in the NEPA process at the earliest possible time.
2. Participate in the scoping process.
3. Assume, on request of the lead agency, responsibility for developing information and preparing environmental analyses, including portions of the environmental impact statement for which the cooperating agency has special expertise.
4. Make available staff support at the lead agency's request to enhance the latter's interdisciplinary capability.
5. Use their own funds.

DoD views this agreement as important to the successful completion of the NEPA process for the MIRC EIS. DoD's goal is to complete the analysis as expeditiously as possible, while using the best scientific information available. The Draft EIS is scheduled for public review in

February 2009 with the Final EIS released in October 2009, and the Record of Decision for this EIS published in December 2009. Your assistance will be invaluable in that endeavor.

We appreciate your consideration of our request and look forward to your response. Should you have any questions or need additional information, please contact Mr. Neil Sheehan, COMPACFLT N01CE13, at (808) 474-7836, or by email at neil.a.sheehan.ctr@navy.mil.

Sincerely,

W. D. FRENCH
Rear Admiral, U.S. Navy

Copy to:
Assistant Secretary of the Navy (Installations & Environment)
Deputy Assistant Secretary of the Navy (Installations & Environment)
Office of Assistant General Council (Installations & Environment)
Commander, Navy Installations Command
Commander, Pacific Fleet N01CE
Commander, Pacific Fleet N7 (Mr. Long)
Naval Facilities Engineering Command, Pacific (Environmental)
Naval Facilities Engineering Command, Marianas (Environmental)

DEPARTMENT OF THE NAVY
U.S. DEFENSE REPRESENTATIVE GUAM/ COMMONWEALTH OF THE
NORTHERN MARIANA ISLANDS/
FEDERATED STATES OF MICRONESIA/ REPUBLIC OF PALAU
PSC 455 BOX 152
FPO AP 96540-1000

IN REPLY REFER TO:

3500
Ser N00/ 0257
September 6, 2007

CERTIFIED MAIL – RETURN RECEIPT REQUESTED

Marion C. Blakey
Administrator, Federal Aviation Administration
800 Independence Ave., SW
Washington, DC 20591

Dear Marion C. Blakey:

SUBJECT: MARIANA ISLANDS RANGE COMPLEX ENVIRONMENTAL IMPACT STATEMENT – COOPERATING AGENCY

The U.S. Department of Defense (DoD) has initiated an Environmental Impact Statement (EIS) to address the potential environmental impacts of proposed military training, research and development, and testing within the Mariana Islands Range Complex (MIRC). As an update to the 1999 EIS for Military Training in the Marianas, the MIRC EIS will analyze military training activities throughout Guam and the Commonwealth of Northern Mariana Islands (CNMI). The Commander, U.S. Pacific Fleet (COMPACFLT), on behalf of the Department of the Navy, will act as Executive Agent for DoD in completing this EIS. DoD requests your participation in this EIS as a cooperating agency pursuant to the National Environmental Policy Act and associated regulations.

DoD will study the environmental effects of increasing usage and enhancing the capability of the MIRC to achieve and maintain military readiness across all Service components, and to conduct current, emerging, and future training and research, development, testing, and evaluation (RDT&E) operations. The No-Action Alternative is the continuation of the current volume and types of training, RDT&E activities, and base operations that was approved in the 1999 EIS for Military Training in the Marianas. This includes all multi-Service training activities and operations on military ranges and training areas including: Andersen Air Force Base (Main Base, Northwest Field, Andersen South, and Tarague Beach); Commander, U.S. Naval Forces Marianas, and its off-shore areas; Farallon de Medinilla; Tinian; Saipan; Rota; and Air Traffic Control Assigned Airspace.

Two action alternatives are proposed. Alternative 1 includes the activities described in the No-Action Alternative with the addition of an increase in current training operations on existing ranges and training areas to support military units located either permanently or temporarily in DoD Area of Responsibility (AOR). Alternative 2 would include all the operations described in Alternative 1 with the addition of new types of operations on existing ranges and training areas and adjacent air and ocean areas. A complete description of the alternatives will be provided in the Description of Proposed Action and Alternatives, which is currently being completed.

In order to adequately evaluate the potential environmental effects of this proposed action, DoD and the Federal Aviation Administration need to work together in assessing potential impacts to training activities and operations within the joint MIRC study area. It is DoD's desire to formalize this relationship as outlined in CEQ guidelines (40 CFR Part 1501.6).

As defined in 40 CFR 1501.6, DoD is the lead agency for the MIRC EIS. The MIRC EIS is funded through the Navy's Tactical Training Theater Assessment and Planning (TAP) program. COMPACFLT will process the MIRC EIS in accordance with other TAP documents to ensure consistency. The Chief of Navy Operations and the Assistant Secretary of the Navy (Installations and Environment) will provide concurrence prior to public release of the draft and final documents. DoD is requesting that the Federal Aviation Administration be a cooperating agency as defined in 40 CFR 1501.6.

Per 40 CFR 1501.6 DoD as the lead agency shall:

1. Request the participation of each cooperating agency in the NEPA process at the earliest possible time.
2. Use the environmental analysis and proposals of cooperating agencies with jurisdiction by law or special expertise, to the maximum extent possible consistent with its responsibility as lead agency.
3. Meet with a cooperating agency at the latter's request.

Each cooperating agency shall:

1. Participate in the NEPA process at the earliest possible time.
2. Participate in the scoping process.
3. Assume, on request of the lead agency, responsibility for developing information and preparing environmental analyses, including portions of the environmental impact statement for which the cooperating agency has special expertise.
4. Make available staff support at the lead agency's request to enhance the latter's interdisciplinary capability.
5. Use their own funds.

DoD views this agreement as important to the successful completion of the NEPA process for the MIRC EIS. DoD's goal is to complete the analysis as expeditiously as possible, while using the best scientific information available. The Draft EIS is scheduled for public review in February 2009 with the Final EIS released in October 2009, and the Record of Decision for this EIS published in December 2009. Your assistance will be invaluable in that endeavor.

We appreciate your consideration of our request and look forward to your response. Should you have any questions or need additional information, please contact Mr. Neil Sheehan, COMPACFLT N01CE13, at (808) 474-7836, or by e-mail at neil.a.sheehan.ctr@navy.mil.

Sincerely,

W. D. FRENCH
Rear Admiral, U.S. Navy

Copy to:
Assistant Secretary of the Navy (Installations & Environment)
Deputy Assistant Secretary of the Navy (Installations & Environment)
Office of Assistant General Council (Installations & Environment)
Commander, Navy Installations Command
Commander, Pacific Fleet N01CE
Commander, Pacific Fleet N7 (Mr. Long)
Naval Facilities Engineering Command, Pacific (Environmental)
Naval Facilities Engineering Command, Marianas (Environmental)

DEPARTMENT OF THE NAVY
U.S. DEFENSE REPRESENTATIVE GUAM/ COMMONWEALTH OF THE
NORTHERN MARIANA ISLANDS/
FEDERATED STATES OF MICRONESIA/ REPUBLIC OF PALAU
PSC 455 BOX 152
FPO AP 96540-1000

IN REPLY REFER TO:

3500
Ser N00/ 0259
September 6, 2007

CERTIFIED MAIL – RETURN RECEIPT REQUESTED

Commander, 196th Infantry Brigade
Headquarters Bldg 525
Fort Shafter, HI 96858-5300

Dear Colonel Tom Guthrie:

SUBJECT: MARIANA ISLANDS RANGE COMPLEX ENVIRONMENTAL IMPACT STATEMENT – COOPERATING AGENCY

The U.S. Department of Defense (DoD) has initiated an Environmental Impact Statement (EIS) to address the potential environmental impacts of proposed military training, research and development, and testing within the Mariana Islands Range Complex (MIRC). As an update to the 1999 EIS for Military Training in the Marianas, the MIRC EIS will analyze military training activities throughout Guam and the Commonwealth of Northern Mariana Islands (CNMI). The Commander, U.S. Pacific Fleet (COMPACFLT), on behalf of the Department of the Navy, will act as Executive Agent for DoD in completing this EIS. DoD requests your participation in this EIS as a cooperating agency pursuant to the National Environmental Policy Act and associated regulations.

DoD will study the environmental effects of increasing usage and enhancing the capability of the MIRC to achieve and maintain military readiness across all Service components, and to conduct current, emerging, and future training and research, development, testing, and evaluation (RDT&E) operations. The No-Action Alternative is the continuation of the current volume and types of training, RDT&E activities, and base operations that was approved in the 1999 EIS for Military Training in the Marianas. This includes all multi-Service training activities and operations on military ranges and training areas including: Andersen Air Force Base (Main Base, Northwest Field, Andersen South, and Tarague Beach); Commander, U.S. Naval Forces Marianas, and its off-shore areas; Farallon de Medinilla; Tinian; Saipan; Rota; and Air Traffic Control Assigned Airspace.

Two action alternatives are proposed. Alternative 1 includes the activities described in the No-Action Alternative with the addition of an increase in current training operations on existing ranges and training areas to support military units located either permanently or temporarily in DoD Area of Responsibility (AOR). Alternative 2 would include all the operations described in Alternative 1 with the addition of new types of operations on existing ranges and training areas and adjacent air and ocean areas. A complete description of the alternatives will be provided in the Description of Proposed Action and Alternatives, which is currently being completed.

In order to adequately evaluate the potential environmental effects of this proposed action, DoD components need to work together in assessing potential impacts to training activities and operations within the joint MIRC study area. It is DoD's desire to formalize this relationship as outlined in CEQ guidelines (40 CFR Part 1501.6).

As defined in 40 CFR 1501.6, DoD is the lead agency for the MIRC EIS. The MIRC EIS is funded through the Navy's Tactical Training Theater Assessment and Planning (TAP) program. COMPACFLT will process the MIRC EIS in accordance with other TAP documents to ensure consistency. The Chief of Naval Operations and the Assistant Secretary of the Navy (Installations and Environment) will provide concurrence prior to public release of the draft and final documents. DoD is requesting that the HQ 196th Infantry Brigade be a cooperating agency as defined in 40 CFR 1501.6.

Per 40 CFR 1501.6 DoD as the lead agency shall:

1. Request the participation of each cooperating agency in the NEPA process at the earliest possible time.
2. Use the environmental analysis and proposals of cooperating agencies with jurisdiction by law or special expertise, to the maximum extent possible consistent with its responsibility as lead agency.
3. Meet with a cooperating agency at the latter's request.

Each cooperating agency shall:

1. Participate in the NEPA process at the earliest possible time.
2. Participate in the scoping process.
3. Assume, on request of the lead agency, responsibility for developing information and preparing environmental analyses, including portions of the environmental impact statement for which the cooperating agency has special expertise.
4. Make available staff support at the lead agency's request to enhance the latter's interdisciplinary capability.
5. Use their own funds.

DoD views this agreement as important to the successful completion of the NEPA process for the MIRC EIS. DoD's goal is to complete the analysis as expeditiously as possible, while using the best scientific information available. The Draft EIS is scheduled for public review in February 2009 with the Final EIS released in October 2009, and the Record of Decision for this EIS published in December 2009. Your assistance will be invaluable in that endeavor.

3500
Ser N00/ 0259
September 6, 2007

We appreciate your consideration of our request and look forward to your response. Should you have any questions or need additional information, please contact Mr. Neil Sheehan, COMPACFLT N01CE13, at (808) 474-7836, or by email at neil.a.sheehan.ctr@navy.mil.

Sincerely,

W. D. FRENCH
Rear Admiral, U.S. Navy

Copy to:
Assistant Secretary of the Navy (Installations & Environment)
Deputy Assistant Secretary of the Navy (Installations & Environment)
Office of Assistant General Council (Installations & Environment)
Commander, Navy Installations Command
Commander, Pacific Fleet N01CE
Commander, Pacific Fleet N7 (Mr. Long)
Naval Facilities Engineering Command, Pacific (Environmental)
Naval Facilities Engineering Command, Marianas (Environmental)

DEPARTMENT OF THE NAVY
U.S. DEFENSE REPRESENTATIVE GUAM/ COMMONWEALTH OF THE
NORTHERN MARIANA ISLANDS/
FEDERATED STATES OF MICRONESIA/ REPUBLIC OF PALAU
PSC 455 BOX 152
FPO AP 96540-1000

IN REPLY REFER TO:

3500
Ser N00/ 0252
September 6, 2007

CERTIFIED MAIL – RETURN RECEIPT REQUESTED

Commander, Marine Corps Bases Pacific
Marine Corps Bases Hawaii
P.O. Box 64119
Camp H.M. Smith, HI 96861-4119

Attention: Director, Marine Corps Installations MidPac

Dear Colonel Burton:

SUBJECT: MARIANA ISLANDS RANGE COMPLEX ENVIRONMENTAL IMPACT STATEMENT – COOPERATING AGENCY

The U.S. Department of Defense (DoD) has initiated an Environmental Impact Statement (EIS) to address the potential environmental impacts of proposed military training, research and development, and testing within the Mariana Islands Range Complex (MIRC). As an update to the 1999 EIS for Military Training in the Marianas, the MIRC EIS will analyze military training activities throughout Guam and the Commonwealth of Northern Mariana Islands (CNMI). The Commander, U.S. Pacific Fleet (COMPACFLT), on behalf of the Department of the Navy, will act as Executive Agent for DoD in completing this EIS. DoD requests your participation in this EIS as a cooperating agency pursuant to the National Environmental Policy Act and associated regulations.

DoD will study the environmental effects of increasing usage and enhancing the capability of the MIRC to achieve and maintain military readiness across all Service components, and to conduct current, emerging, and future training and research, development, testing, and evaluation (RDT&E) operations. The No-Action Alternative is the continuation of the current volume and types of training, RDT&E activities, and base operations that was approved in the 1999 EIS for Military Training in the Marianas. This includes all multi-Service training activities and operations on military ranges and training areas including: Andersen Air Force Base (Main Base, Northwest Field, Andersen South, and Tarague Beach); Commander, U.S. Naval Forces Marianas, and its off-shore areas; Farallon de Medinilla; Tinian; Saipan; Rota; and Air Traffic Control Assigned Airspace.

Two action alternatives are proposed. Alternative 1 includes the activities described in the No-Action Alternative with the addition of an increase in current training operations on existing ranges and training areas to support military units located either permanently or temporarily in DoD Area of Responsibility (AOR). Alternative 2 would include all the operations described in Alternative 1 with the addition of new types of operations on existing ranges and training areas

and adjacent air and ocean areas. A complete description of the alternatives will be provided in the Description of Proposed Action and Alternatives, which is currently being completed.

In order to adequately evaluate the potential environmental effects of this proposed action, DoD components need to work together in assessing potential impacts to training activities and operations within the joint MIRC study area. It is DoD's desire to formalize this relationship as outlined in CEQ guidelines (40 CFR Part 1501.6).

As defined in 40 CFR 1501.6, DoD is the lead agency for the MIRC EIS. The MIRC EIS is funded through the Navy's Tactical Training Theater Assessment and Planning (TAP) program. COMPACFLT will process the MIRC EIS in accordance with other TAP documents to ensure consistency. The Chief of Navy Operations and the Assistant Secretary of the Navy (Installations and Environment) will provide concurrence prior to public release of the draft and final documents. DoD is requesting that the Marine Corps be a cooperating agency as defined in 40 CFR 1501.6.

Per 40 CFR 1501.6 DoD as the lead agency shall:

1. Request the participation of each cooperating agency in the NEPA process at the earliest possible time.
2. Use the environmental analysis and proposals of cooperating agencies with jurisdiction by law or special expertise, to the maximum extent possible consistent with its responsibility as lead agency.
3. Meet with a cooperating agency at the latter's request.

Each cooperating agency shall:

1. Participate in the NEPA process at the earliest possible time.
2. Participate in the scoping process.
3. Assume, on request of the lead agency, responsibility for developing information and preparing environmental analyses, including portions of the environmental impact statement for which the cooperating agency has special expertise.
4. Make available staff support at the lead agency's request to enhance the latter's interdisciplinary capability.
5. Use their own funds.

DoD views this agreement as important to the successful completion of the NEPA process for the MIRC EIS. DoD's goal is to complete the analysis as expeditiously as possible, while using the best scientific information available. The Draft EIS is scheduled for public review in February 2009 with the Final EIS released in October 2009, and the Record of Decision for this EIS published in December 2009. Your assistance will be invaluable in that endeavor.

We appreciate your consideration of our request and look forward to your response. Should you have any questions or need additional information, please contact Mr. Neil Sheehan, COMPACFLT N01CE13, at (808) 474-7836, or by email at neil.a.sheehan.ctr@navy.mil.

Sincerely,

W. D. FRENCH
Rear Admiral, U.S. Navy

Copy to:
Assistant Secretary of the Navy (Installations & Environment)
Deputy Assistant Secretary of the Navy (Installations & Environment)
Office of Assistant General Council (Installations & Environment)
Commander, Navy Installations Command
Commander, Pacific Fleet N01CE
Commander, Pacific Fleet N7 (Mr. Long)
Naval Facilities Engineering Command, Pacific (Environmental)
Naval Facilities Engineering Command, Marianas (Environmental)

DEPARTMENT OF THE NAVY
U.S. DEFENSE REPRESENTATIVE GUAM/ COMMONWEALTH OF THE NORTHERN MARIANA ISLANDS/
FEDERATED STATES OF MICRONESIA/ REPUBLIC OF PALAU
PSC 455 BOX 152
FPO AP 96540-1000

IN REPLY REFER TO:

3500
Ser N00/ 0255
September 6, 2007

CERTIFIED MAIL – RETURN RECEIPT REQUESTED

Mr. Kevin Billings
Deputy Assistant Secretary (Environment, Safety and Occupational Health)
HQ SAF/IEE
1665 Air Force Pentagon
Washington, DC 20330-1665

Dear Mr. Billings:

SUBJECT: MARIANA ISLANDS RANGE COMPLEX ENVIRONMENTAL IMPACT STATEMENT – COOPERATING AGENCY

The U.S. Department of Defense (DoD) has initiated an Environmental Impact Statement (EIS) to address the potential environmental impacts of proposed military training, research and development, and testing within the Mariana Islands Range Complex (MIRC). As an update to the 1999 EIS for Military Training in the Marianas, the MIRC EIS will analyze military training activities throughout Guam and the Commonwealth of Northern Mariana Islands (CNMI). The Commander, U.S. Pacific Fleet (COMPACFLT), on behalf of the Department of the Navy, will act as Executive Agent for DoD in completing this EIS. DoD requests your participation in this EIS as a cooperating agency pursuant to the National Environmental Policy Act and associated regulations.

DoD will study the environmental effects of increasing usage and enhancing the capability of the MIRC to achieve and maintain military readiness across all Service components, and to conduct current, emerging, and future training and research, development, testing, and evaluation (RDT&E) operations. The No-Action Alternative is the continuation of the current volume and types of training, RDT&E activities, and base operations that was approved in the 1999 EIS for Military Training in the Marianas. This includes all multi-Service training activities and operations on military ranges and training areas including: Andersen Air Force Base (Main Base, Northwest Field, Andersen South, and Tarague Beach); Commander, U.S. Naval Forces Marianas, and its off-shore areas; Farallon de Medinilla; Tinian; Saipan; Rota; and Air Traffic Control Assigned Airspace.

Two action alternatives are proposed. Alternative 1 includes the activities described in the No-Action Alternative with the addition of an increase in current training operations on existing ranges and training areas to support military units located either permanently or temporarily in DoD Area of Responsibility (AOR). Alternative 2 would include all the operations described in Alternative 1 with the addition of new types of operations on existing ranges and training areas

and adjacent air and ocean areas. A complete description of the alternatives will be provided in the Description of Proposed Action and Alternatives, which is currently being completed.

In order to adequately evaluate the potential environmental effects of this proposed action, DoD components need to work together in assessing potential impacts to training activities and operations within the joint MIRC study area. It is DoD's desire to formalize this relationship as outlined in CEQ guidelines (40 CFR Part 1501.6).

As defined in 40 CFR 1501.6, DoD is the lead agency for the MIRC EIS. The MIRC EIS is funded through the Navy's Tactical Training Theater Assessment and Planning (TAP) program. COMPACFLT will process the MIRC EIS in accordance with other TAP documents to ensure consistency. The Chief of Navy Operations and the Assistant Secretary of the Navy (Installations and Environment) will provide concurrence prior to public release of the draft and final documents. DoD is requesting that the U.S. Air Force be a cooperating agency as defined in 40 CFR 1501.6.

Per 40 CFR 1501.6 DoD as the lead agency shall:

1. Request the participation of each cooperating agency in the NEPA process at the earliest possible time.
2. Use the environmental analysis and proposals of cooperating agencies with jurisdiction by law or special expertise, to the maximum extent possible consistent with its responsibility as lead agency.
3. Meet with a cooperating agency at the latter's request.

Each cooperating agency shall:

1. Participate in the NEPA process at the earliest possible time.
2. Participate in the scoping process.
3. Assume, on request of the lead agency, responsibility for developing information and preparing environmental analyses, including portions of the environmental impact statement for which the cooperating agency has special expertise.
4. Make available staff support at the lead agency's request to enhance the latter's interdisciplinary capability.
5. Use their own funds.

DoD views this agreement as important to the successful completion of the NEPA process for the MIRC EIS. DoD's goal is to complete the analysis as expeditiously as possible, while using the best scientific information available. The Draft EIS is scheduled for public review in February 2009 with the Final EIS released in October 2009, and the Record of Decision for this EIS published in December 2009. Your assistance will be invaluable in that endeavor.

We appreciate your consideration of our request and look forward to your response. Should you have any questions or need additional information, please contact Mr. Neil Sheehan, COMPACFLT N01CE13, at (808) 474-7836, or by email at neil.a.sheehan.ctr@navy.mil.

Sincerely,

W. D. FRENCH
Rear Admiral, U.S. Navy

Copy to:
Assistant Secretary of the Navy (Installations & Environment)
Deputy Assistant Secretary of the Navy (Installations & Environment)
Office of Assistant General Council (Installations & Environment)
Commander, Navy Installations Command
Commander, Pacific Fleet N01CE
Commander, Pacific Fleet N7 (Mr. Long)
Naval Facilities Engineering Command, Pacific (Environmental)
Naval Facilities Engineering Command, Marianas (Environmental)

DEPARTMENT OF THE NAVY
U.S. DEFENSE REPRESENTATIVE GUAM/ COMMONWEALTH OF THE
NORTHERN MARIANA ISLANDS/
FEDERATED STATES OF MICRONESIA/ REPUBLIC OF PALAU
PSC 455 BOX 152
FPO AP 96540-1000

IN REPLY REFER TO:

3500
Ser N00/ 0256
September 6, 2007

CERTIFIED MAIL – RETURN RECEIPT REQUESTED

Commander, U.S. Coast Guard Sector Guam
PSC 455 Box 176
FPO AP 96540-1056

Dear Captain Marhoffer:

SUBJECT: MARIANA ISLANDS RANGE COMPLEX ENVIRONMENTAL IMPACT STATEMENT – COOPERATING AGENCY

The U.S. Department of Defense (DoD) has initiated an Environmental Impact Statement (EIS) to address the potential environmental impacts of proposed military training, research and development, and testing within the Mariana Islands Range Complex (MIRC). As an update to the 1999 EIS for Military Training in the Marianas, the MIRC EIS will analyze military training activities throughout Guam and the Commonwealth of Northern Mariana Islands (CNMI). The Commander, U.S. Pacific Fleet (COMPACFLT), on behalf of the Department of the Navy, will act as Executive Agent for DoD in completing this EIS. DoD requests your participation in this EIS as a cooperating agency pursuant to the National Environmental Policy Act and associated regulations.

DoD will study the environmental effects of increasing usage and enhancing the capability of the MIRC to achieve and maintain military readiness across all Service components, and to conduct current, emerging, and future training and research, development, testing, and evaluation (RDT&E) operations. The No-Action Alternative is the continuation of the current volume and types of training, RDT&E activities, and base operations that was approved in the 1999 EIS for Military Training in the Marianas. This includes all multi-Service training activities and operations on military ranges and training areas including: Andersen Air Force Base (Main Base, Northwest Field, Andersen South, and Tarague Beach); Commander, U.S. Naval Forces Marianas and its off-shore areas; Farallon de Medinilla; Tinian; Saipan; Rota; and Air Traffic Control Assigned Airspace.

Two action alternatives are proposed. Alternative 1 includes the activities described in the No-Action Alternative with the addition of an increase in current training operations on existing ranges and training areas to support military units located either permanently or temporarily in DoD Area of Responsibility (AOR). Alternative 2 would include all the operations described in Alternative 1 with the addition of new types of operations on existing ranges and training areas and adjacent air and ocean areas. A complete description of the alternatives will be provided in the Description of Proposed Action and Alternatives, which is currently being completed.

3500
Ser N00/ 0256
September 6, 2007

In order to adequately evaluate the potential environmental effects of this proposed action, DoD and the U.S. Coast Guard need to work together in assessing potential impacts to training activities and operations within the joint MIRC study area. It is DoD's desire to formalize this relationship as outlined in CEQ guidelines (40 CFR Part 1501.6).

As defined in 40 CFR 1501.6, DoD is the lead agency for the MIRC EIS. The MIRC EIS is funded through the Navy's Tactical Training Theater Assessment and Planning (TAP) program. COMPACFLT will process the MIRC EIS in accordance with other TAP documents to ensure consistency. The Chief of Navy Operations and the Assistant Secretary of the Navy (Installations and Environment) will provide concurrence prior to public release of the draft and final documents. DoD is requesting that the Coast Guard Sector Guam be a cooperating agency as defined in 40 CFR 1501.6.

Per 40 CFR 1501.6 DoD as the lead agency shall:

1. Request the participation of each cooperating agency in the NEPA process at the earliest possible time.
2. Use the environmental analysis and proposals of cooperating agencies with jurisdiction by law or special expertise, to the maximum extent possible consistent with its responsibility as lead agency.
3. Meet with a cooperating agency at the latter's request.

Each cooperating agency shall:

1. Participate in the NEPA process at the earliest possible time.
2. Participate in the scoping process.
3. Assume, on request of the lead agency, responsibility for developing information and preparing environmental analyses, including portions of the environmental impact statement for which the cooperating agency has special expertise.
4. Make available staff support at the lead agency's request to enhance the latter's interdisciplinary capability.
5. Use their own funds.

DoD views this agreement as important to the successful completion of the NEPA process for the MIRC EIS. DoD's goal is to complete the analysis as expeditiously as possible, while using the best scientific information available. The Draft EIS is scheduled for public review in February 2009 with the Final EIS released in October 2009, and the Record of Decision for this EIS published in December 2009. Your assistance will be invaluable in that endeavor.

3500
Ser N00/ 0256
September 6, 2007

We appreciate your consideration of our request and look forward to your response. Should you have any questions or need additional information, please contact Mr. Neil Sheehan, COMPACFLT N01CE13, at (808) 474-7836, or by email at neil.a.sheehan.ctr@navy.mil.

Sincerely,

W. D. FRENCH
Rear Admiral, U.S. Navy

Copy to:
Assistant Secretary of the Navy (Installations & Environment)
Deputy Assistant Secretary of the Navy (Installations & Environment)
Office of Assistant General Council (Installations & Environment)
Commander, Navy Installations Command
Commander, Pacific Fleet N01CE
Commander, Pacific Fleet N7 (Mr. Long)
Naval Facilities Engineering Command, Pacific (Environmental)
Naval Facilities Engineering Command, Marianas (Environmental)

DEPARTMENT OF THE NAVY

U.S. DEFENSE REPRESENTATIVE GUAM/ COMMONWEALTH OF THE NORTHERN MARIANA ISLANDS/ FEDERATED STATES OF MICRONESIA/ REPUBLIC OF PALAU
PSC 455 BOX 152
FPO AP 96540-1000

IN REPLY REFER TO:

3500
Ser N00/ 0253
September 6, 2007

CERTIFIED MAIL – RETURN RECEIPT REQUESTED

Commanding General
U.S. Army Reserve
9th Regional Readiness Command
1557 Pass Street
Fort Shafter Flats
Honolulu, Hawaii 96819

Dear Brigadier General Alexander Kozolv:

SUBJECT: MARIANA ISLANDS RANGE COMPLEX ENVIRONMENTAL IMPACT STATEMENT – COOPERATING AGENCY

The U.S. Department of Defense (DoD) has initiated an Environmental Impact Statement (EIS) to address the potential environmental impacts of proposed military training, research and development, and testing within the Mariana Islands Range Complex (MIRC). As an update to the 1999 EIS for Military Training in the Marianas, the MIRC EIS will analyze military training activities throughout Guam and the Commonwealth of Northern Mariana Islands (CNMI). The Commander, U.S. Pacific Fleet (COMPACFLT), on behalf of the Department of the Navy, will act as Executive Agent for DoD in completing this EIS. DoD requests your participation in this EIS as a cooperating agency pursuant to the National Environmental Policy Act and associated regulations.

DoD will study the environmental effects of increasing usage and enhancing the capability of the MIRC to achieve and maintain military readiness across all Service components, and to conduct current, emerging, and future training and research, development, testing, and evaluation (RDT&E) operations. The No-Action Alternative is the continuation of the current volume and types of training, RDT&E activities, and base operations that was approved in the 1999 EIS for Military Training in the Marianas. This includes all multi-Service training activities and operations on military ranges and training areas including: Andersen Air Force Base (Main Base, Northwest Field, Andersen South, and Tarague Beach); Commander, U.S. Naval Forces Marianas and its off-shore areas; Farallon de Medinilla; Tinian; Saipan; Rota; and Air Traffic Control Assigned Airspace.

Two action alternatives are proposed. Alternative 1 includes the activities described in the No-Action Alternative with the addition of an increase in current training operations on existing ranges and training areas to support military units located either permanently or temporarily in DoD Area of Responsibility (AOR). Alternative 2 would include all the operations described in Alternative 1 with the addition of new types of operations on existing ranges and training areas

and adjacent air and ocean areas. A complete description of the alternatives will be provided in the Description of Proposed Action and Alternatives, which is currently being completed.

In order to adequately evaluate the potential environmental effects of this proposed action, DoD components need to work together in assessing potential impacts to training activities and operations within the joint MIRC study area. It is DoD's desire to formalize this relationship as outlined in CEQ guidelines (40 CFR Part 1501.6).

As defined in 40 CFR 1501.6, DoD is the lead agency for the MIRC EIS. The MIRC EIS is funded through the Navy's Tactical Training Theater Assessment and Planning (TAP) program. COMPACFLT will process the MIRC EIS in accordance with other TAP documents to ensure consistency. The Chief of Navy Operations and the Assistant Secretary of the Navy (Installations and Environment) will provide concurrence prior to public release of the draft and final documents. DoD is requesting that the U.S. Army Reserve be a cooperating agency as defined in 40 CFR 1501.6.

Per 40 CFR 1501.6 DoD as the lead agency shall:

1. Request the participation of each cooperating agency in the NEPA process at the earliest possible time.
2. Use the environmental analysis and proposals of cooperating agencies with jurisdiction by law or special expertise, to the maximum extent possible consistent with its responsibility as lead agency.
3. Meet with a cooperating agency at the latter's request.

Each cooperating agency shall:

1. Participate in the NEPA process at the earliest possible time.
2. Participate in the scoping process.
3. Assume, on request of the lead agency, responsibility for developing information and preparing environmental analyses, including portions of the environmental impact statement for which the cooperating agency has special expertise.
4. Make available staff support at the lead agency's request to enhance the latter's interdisciplinary capability.
5. Use their own funds.

DoD views this agreement as important to the successful completion of the NEPA process for the MIRC EIS. DoD's goal is to complete the analysis as expeditiously as possible, while using the best scientific information available. The Draft EIS is scheduled for public review in

3500
Ser N00/ 0253
September 6, 2007

February 2009 with the Final EIS released in October 2009, and the Record of Decision for this EIS published in December 2009. Your assistance will be invaluable in that endeavor.

We appreciate your consideration of our request and look forward to your response. Should you have any questions or need additional information, please contact Mr. Neil Sheehan, COMPACFLT N01CE13, at (808) 474-7836, or by email at neil.a.sheehan.ctr@navy.mil.

Sincerely,

W. D. French
Rear Admiral, U.S. Navy

Copy to:
Assistant Secretary of the Navy (Installations & Environment)
Deputy Assistant Secretary of the Navy (Installations & Environment)
Office of Assistant General Council (Installations & Environment)
Commander, Navy Installations Command
Commander, Pacific Fleet N01CE
Commander, Pacific Fleet N7 (Mr. Long)
Naval Facilities Engineering Command, Pacific (Environmental)
Naval Facilities Engineering Command, Marianas (Environmental)

DEPARTMENT OF THE NAVY
U.S. DEFENSE REPRESENTATIVE GUAM/ COMMONWEALTH OF THE
NORTHERN MARIANA ISLANDS/
FEDERATED STATES OF MICRONESIA/ REPUBLIC OF PALAU
PSC 455 BOX 152
FPO AP 96540-1000

IN REPLY REFER TO:

3500
Ser N00/ 0258
September 6, 2007

CERTIFIED MAIL – RETURN RECEIPT REQUESTED

Adjutant General
Guam National Guard
430 Army Drive Bld 300, Rm 113
Barrigada, Guam 96913-4421

Dear Major General Goldhorn:

SUBJECT: MARIANA ISLANDS RANGE COMPLEX ENVIRONMENTAL IMPACT STATEMENT – COOPERATING AGENCY

The U.S. Department of Defense (DoD) has initiated an Environmental Impact Statement (EIS) to address the potential environmental impacts of proposed military training, research and development, and testing within the Mariana Islands Range Complex (MIRC). As an update to the 1999 EIS for Military Training in the Marianas, the MIRC EIS will analyze military training activities throughout Guam and the Commonwealth of Northern Mariana Islands (CNMI). The Commander, U.S. Pacific Fleet (COMPACFLT), on behalf of the Department of the Navy, will act as Executive Agent for DoD in completing this EIS. DoD requests your participation in this EIS as a cooperating agency pursuant to the National Environmental Policy Act and associated regulations.

DoD will study the environmental effects of increasing usage and enhancing the capability of the MIRC to achieve and maintain military readiness across all Service components, and to conduct current, emerging, and future training and research, development, testing, and evaluation (RDT&E) operations. The No-Action Alternative is the continuation of the current volume and types of training, RDT&E activities, and base operations that was approved in the 1999 EIS for Military Training in the Marianas. This includes all multi-Service training activities and operations on military ranges and training areas including: Andersen Air Force Base (Main Base, Northwest Field, Andersen South, and Tarague Beach); Commander, U.S. Naval Forces Marianas, and its off-shore areas; Farallon de Medinilla; Tinian; Saipan; Rota; and Air Traffic Control Assigned Airspace.

Two action alternatives are proposed. Alternative 1 includes the activities described in the No-Action Alternative with the addition of an increase in current training operations on existing ranges and training areas to support military units located either permanently or temporarily in DoD Area of Responsibility (AOR). Alternative 2 would include all the operations described in Alternative 1 with the addition of new types of operations on existing ranges and training areas and adjacent air and ocean areas. A complete description of the alternatives will be provided in the Description of Proposed Action and Alternatives, which is currently being completed.

In order to adequately evaluate the potential environmental effects of this proposed action, DoD and the Guam National Guard need to work together in assessing potential impacts to training activities and operations within the joint MIRC study area. It is DoD's desire to formalize this relationship as outlined in CEQ guidelines (40 CFR Part 1501.6).

As defined in 40 CFR 1501.6, DoD is the lead agency for the MIRC EIS. The MIRC EIS is funded through the Navy's Tactical Training Theater Assessment and Planning (TAP) program. COMPACFLT will process the MIRC EIS in accordance with other TAP documents to ensure consistency. The Chief of Navy Operations and the Assistant Secretary of the Navy (Installations and Environment) will provide concurrence prior to public release of the draft and final documents. DoD is requesting that the Joint Force Headquarters - Guam be a cooperating agency as defined in 40 CFR 1501.6.

Per 40 CFR 1501.6 DoD as the lead agency shall:

1. Request the participation of each cooperating agency in the NEPA process at the earliest possible time.
2. Use the environmental analysis and proposals of cooperating agencies with jurisdiction by law or special expertise, to the maximum extent possible consistent with its responsibility as lead agency.
3. Meet with a cooperating agency at the latter's request.

Each cooperating agency shall:

1. Participate in the NEPA process at the earliest possible time.
2. Participate in the scoping process.
3. Assume, on request of the lead agency, responsibility for developing information and preparing environmental analyses, including portions of the environmental impact statement for which the cooperating agency has special expertise.
4. Make available staff support at the lead agency's request to enhance the latter's interdisciplinary capability.
5. Use their own funds.

DoD views this agreement as important to the successful completion of the NEPA process for the MIRC EIS. DoD's goal is to complete the analysis as expeditiously as possible, while using the best scientific information available. The Draft EIS is scheduled for public review in February 2009 with the Final EIS released in October 2009, and the Record of Decision for this EIS published in December 2009. Your assistance will be invaluable in that endeavor.

3500
Ser N00/ 0258
September 6, 2007

We appreciate your consideration of our request and look forward to your response. Should you have any questions or need additional information, please contact Mr. Neil Sheehan, COMPACFLT N01CE13, at (808) 474-7836, or by email at neil.a.sheehan.ctr@navy.mil.

Sincerely,

W. D. FRENCH
Rear Admiral, U.S. Navy

Copy to:
Assistant Secretary of the Navy (Installations & Environment)
Deputy Assistant Secretary of the Navy (Installations & Environment)
Office of Assistant General Council (Installations & Environment)
Commander, Navy Installations Command
Commander, Pacific Fleet N01CE
Commander, Pacific Fleet N7 (Mr. Long)
Naval Facilities Engineering Command, Pacific (Environmental)
Naval Facilities Engineering Command, Marianas (Environmental)

This Page Intentionally Left Blank

ACCEPTANCE LETTERS

Dr. William T. Hogarth
Assistant Administrator
National Oceanic and Atmospheric
Administration (NOAA) Fisheries
1315 East West Highway
Silver Spring, MD 20910

Mr. James Cason
Associate Deputy Secretary of the Interior
Department of the Interior
1849 C Street, NW
Washington, DC 20240

Mr. Paul C Hubbell
Deputy Assistant Deputy Commandant
Installations and Logistics (Facilities)
Headquarters, USMC
2 Navy Annex
Washington, DC 20380-1775

Edith V. Parish
Acting Director
Systems Operations Airspace and Aeronautical Information Management
Air Traffic Organization
Federal Aviation Administration
800 Independence Avenue, SW.
Washington, DC 20591

This Page Intentionally Left Blank

UNITED STATES DEPARTMENT OF COMMERCE
National Oceanic and Atmospheric Administration
NATIONAL MARINE FISHERIES SERVICE
1315 East-West Highway
Silver Spring, Maryland 20910
THE DIRECTOR

SEP 1 7 2007

Mr. William G. Mattheis
Acting Director, Environmental Readiness Division
Department of the Navy
2000 Navy Pentagon
Washington, DC 20350-2000

Dear Mr. Mattheis:

Thank you for your letter requesting that NOAA's National Marine Fisheries Service (NMFS) be a cooperating agency in the preparation of an Environmental Impact Statement (EIS) to evaluate potential environmental effects of using the Department of the Navy's Mariana Islands Range Complex to achieve and maintain military readiness and to support and conduct training activities and research, development, test, and evaluation events.

We support the Navy's decision to prepare an EIS on these activities and agree to be a cooperating agency, due, in part, to our responsibilities under section 101(a)(5)(A) of the Marine Mammal Protection Act and section 7 of the Endangered Species Act. As agreed upon with Navy staff, NMFS staff will provide comments on draft EISs to the Navy within 28 days of receipt of the document. Otherwise, NMFS will make every effort to support the Navy in the specific ways described in your letter.

If you need any additional information, please contact Ms. Jolie Harrison at (301) 713-2289, ext. 166.

Sincerely,

William T. Hogarth, Ph.D.

This Page Intentionally Left Blank

THE ASSOCIATE DEPUTY SECRETARY OF THE INTERIOR
WASHINGTON

NOV 0 1 2007

Rear Admiral W.D. French, U.S.N.
Department of the Navy
U.S. Defense Representative
PSC 455 Box 152
FPO AP 96540-1000

Dear Admiral French:

Thank you for your September 6, 2007, letter to Secretary Kempthorne requesting the Department of the Interior to become a cooperating agency in the development of an Environmental Impact Statement to address the potential environmental impacts of proposed military training, research and development, and testing within the Mariana Islands Range Complex. We are pleased to accept your request.

The Office of Insular Affairs will be the Department's representative on this effort. Please contact Ms. Faride Komisar at (202) 208-6971, or by email at <faride_komisar@ios.doi.gov> should you have any questions or need additional information.

The Department of the Interior appreciates this opportunity to serve as a cooperating agency and we look forward to working closely with the U.S. Department of Defense during the EIS process.

Sincerely,

James E. Cason

James E. Cason

This Page Intentionally Left Blank

Nova —

09

EV

DEPARTMENT OF THE NAVY
HEADQUARTERS UNITED STATES MARINE CORPS
2 NAVY ANNEX
WASHINGTON, DC 20380-1775

IN REPLY REFER TO:
5090
LF

05 FEB 2008

J.P. Rios, Capt (USN)
Deputy Fleet Civil Engineer
Commander, Pacific Fleet (N01CE1)
250 Makalapa Drive
Pearl Harbor, HI 96860-3131

Dear Captain Rios:

This letter is in response to your 12 December 2007 letter requesting Marine Corps participation as a cooperating agency in the Mariana Islands Range Complex Environmental Impact Statement. The Marine Corps supports this effort and agrees to be a cooperating agency. We stand by ready to support as necessary, in addition to the staff level personnel already supplying support and data to the Commander, U.S. Pacific Fleet.

My point of contact for this matter is Ms. Mary Hassell. She can be contacted at DSN 695-8240, (703) 695-8232, ext. 3346, or email: mary.hassell@usmc.mil.

Sincerely,

Paul C. Hubbell
Deputy Assistant/Deputy Commandant
Installations and Logistics
(Facilities)

Copy to:
ASN (I&E)
DASN (E)
OAGC (I&E)
CNIC
CDR NAVREG MARIANAS
✓NAVFAC PAC (EV)
NAVFAC MAR (EV)

This Page Intentionally Left Blank

U.S. Department
of Transportation
**Federal Aviation
Administration**

System Operations Airspace and
Aeronautical Information Management
800 Independence Ave., SW.
Washington, DC 20591

OCT 9 2007

RECEIVED 19 OCT. 7R

Rear Admiral William D. French
U.S. Defense Representative
Guam/Commonwealth of the
Northern Mariana Islands/
Federated States of Micronesia/
Republic of Palau
PSC 455 Box 152
FPO AP 96540-1000

Dear Admiral French:

Thank you for your letter of September 6, 2007 requesting Federal Aviation Administration participation in the environmental impact statement process associated with the proposed military training, research and development, and testing within the Mariana Islands Range Complex (MIRC).

We are pleased to participate as a cooperating agency, in accordance with the National Environmental Policy Act of 1969, as Amended, and the implementing regulations. Since the proposal contemplates activities associated with Special Use Airspace (SUA), the FAA will cooperate following the guidelines described in the Memorandum of Understanding between the FAA and the Department of Defense Concerning SUA Environmental Actions, dated October 4, 2005.

The FAA Western Service Area will be the primary focal point for environmental matters related to this proposal. I have forwarded a copy of this letter and your letter to the System Support Group Manager, Mr. Clark Desing. You can contact him directly at (425) 917-6700.

We look forward to working with the Navy on the environmental process for the proposed MIRC military training activities throughout Guam and the Commonwealth of Northern Mariana Islands.

Sincerely,

Edith V. Parish
Acting Director, System Operations Airspace & Aeronautical Information Management
Air Traffic Organization

cc with attachment: FAA Western Service Area

This Page Intentionally Left Blank

APPENDIX B

NOTICE OF INTENT

This Page Intentionally Left Blank

Number Of Respondents: 229.

Responses Per Respondent: Approximately 2.

Annual Responses: 453.

Average Burden Per Response: 1 hour (reporting); 3.7 hours (recordkeeping).

Annual Burden Hours: 1,300.

Needs and Uses: DoD needs this information to evaluate whether the purposes of the DoD Pilot Mentor-Protege program have been met. These reports provide data for several reports to Congress required by Section 822 of the National Defense Authorization Act for FY1998 and Section 811 of the National Defense Authorization Act for FY2000.

Affected Public: Business or other for-profit; not-for-profit institutions.

Frequency: Semiannually (mentor); annually (protege).

Respondent's Obligation: Required to obtain or retain benefits.

OMB Desk Officer: Ms. Hillary Jaffe.

Written comments and recommendations on the proposed information collection should be sent to Ms. Jaffe at the Office of Management and Budget, Desk Officer for DoD, Room 10236, New Executive Office Building, Washington, DC 20503.

You may also submit comments, identified by docket number and title, by the following method:

• Federal eRulemaking Portal: *http://www.regulations.gov.* Follow the instructions for submitting comments.

Instructions: All submissions received must include the agency name, docket number and title for this **Federal Register** document. The general policy for comments and other submissions from members of the public is to make these submissions available for public viewing on the Internet at *http://www.regulations.gov* as they are received without change, including any personal identifiers or contact information.

DOD Clearance Officer: Ms. Patricia Toppings.

Written requests for copies of the information collection proposal should be sent to Ms. Toppings at WHS/ESD/Information Management Division, 1777 North Kent Street, RPN, Suite 11000, Arlington, VA 22209–2133

Dated: May 21, 2007.

Patricia L. Toppings,

Alternate OSD Federal Register Liaison Officer, Department of Defense.

[FR Doc. 07–2712 Filed 5–31–07; 8:45 am]

BILLING CODE 5001–06–M

DEPARTMENT OF DEFENSE

Office of the Secretary

[No. DoD–2007–DARS–0053]

Submission for OMB Review; Comment Request

ACTION: Notice.

The Department of Defense has submitted to OMB for clearance, the following proposal for collection of information under the provisions of the Paperwork Reduction Act (44 U.S.C. Chapter 35).

DATES: Consideration will be given to all comments received by July 2, 2007.

Title, Form, and OMB Number: Foreign Acquisition—Defense Federal Acquisition Regulation Supplement Part 225 and Related Clauses at 252.225; DD Form 2139; OMB Control Number 0704–0229.

Type of Request: Revision.

Number of Respondents: 20,485.

Responses Per Respondent: Approximately 8.

Annual Responses: 154,924.

Average Burden Per Response: 31 hours.

Annual Burden Hours: 48,480 (48,385 reporting hours; 95 recordkeeping hours).

Needs and Uses: DoD needs this information to ensure compliance with restrictions on the acquisition of foreign products imposed by statute or policy to protect the industrial base; to ensure compliance with U.S. trade agreements and memoranda of understanding that promote reciprocal trade with U.S. allies; and to prepare reports for submission to the Department of Commerce on the Balance of Payments Program.

Affected Public: Business or other for-profit; not-for-profit institutions.

Frequency: On occasion.

Respondent's Obligation: Required to obtain or retain benefits.

OMB Desk Officer: Ms Hillary Jaffe.

Written comments and recommendations on the proposed information collection should be sent to Ms. Jaffe at the Office of Management and Budget, Desk Officer for DoD, Room 10236, New Executive Office Building, Washington, DC 20503.

You may also submit comments, identified by docket number and title, by the following method:

• Federal eRulemaking Portal: *http://www.regulations.gov.* Follow the instructions for submitting comments.

Instructions: All submissions received must include the agency name, docket number and title for this **Federal Register** document. The general policy for comments and other submissions from members of the public is to make these submissions available for public viewing on the Internet at *http://www.regulations.gov* as they are received without change, including any personal identifiers or contact information.

DOD Clearance Officer: Ms. Patricia Toppings.

Written requests for copies of the information collection proposal should be sent to Ms. Toppings at WHS/ESD/Information Management Division, 1777 North Kent Street, RPN, Suite 11000, Arlington, VA 22209–2133.

Dated: May 21, 2007.

Patricia L. Toppings,

Alternate OSD Federal Register Liaison Officer, Department of Defense.

[FR Doc. 07–2713 Filed 5–31–07; 8:45 am]

BILLING CODE 5001–06–M

DEPARTMENT OF DEFENSE

Defense Representative Guam, Commonwealth of the Northern Mariana Islands, Federated States of Micronesia and Republic of Palau; Notice of Intent To Prepare an Environmental Impact Statement/Overseas Environmental Impact Statement for the Mariana Islands Range Complex and To Announce Public Scoping Meetings

AGENCY: Department of Defense Representative Guam, Commonwealth of the Northern Mariana Islands, Federated States of Micronesia and Republic of Palau.

ACTION: Notice.

SUMMARY: Pursuant to Section 102(2)(c) of the National Environmental Policy Act (NEPA) of 1969, as implemented by the Council on Environmental Quality Regulations (40 CFR parts 1500–1508), and Executive Order 12114 (Environmental Effects Abroad of Major Federal Actions), the Department of Defense Representative Guam, Commonwealth of the Northern Mariana Islands, Federated States of Micronesia and Republic of Palau (DoD REP) announces its intent to prepare an Environmental Impact Statement (EIS)/Overseas Environmental Impact Statement (OEIS) to evaluate the potential environmental impacts associated with conducting military readiness activities in the Mariana Islands Range Complex (MIRC). The DoD REP proposes to support current and emerging training operations and research, development, testing, and evaluation (RDT&E) activities in the MIRC by: (1) Maintaining baseline

operations at current levels; (2) increasing training operations from current levels as necessary to support Military Service training requirements; (3) increasing and accommodating potential RDT&E operations; and (4) implementing new and enhanced range complex capabilities.

Dates and Addresses: Public scoping meetings will be held on Guam, Saipan, and Tinian to receive oral and/or written comments on environmental concerns that should be addressed in the EIS. The public scoping meetings will be held at the following dates, times, and locations:

1. Monday, June 18, 2007, 5 p.m.–8 p.m., Guam Hilton, 202 Hilton Road, Tumon Bay, Guam.

2. Wednesday, June 20, 2007, 5 p.m.–8 p.m., Hyatt Regency Saipan, Garapan Village (Across from American Memorial Park), Garapan, Saipan, CNMI.

3. Thursday, June 21, 2007, 5 p.m.–8 p.m., Dynasty Hotel, One Broadway, San Jose Village, Tinian, CNMI.

Details of the meetings will be announced in local newspapers. Additional information concerning the scoping meetings will be available on the EIS/OEIS Web page located at: *http://www.MarianasRangeComplexEis.com*.

FOR FURTHER INFORMATION CONTACT: LT Donnell Evans, U.S. Naval Forces Marianas Public Affairs Officer, *ATTN:* Code N00PA, PSC 455 Box 152, FPO AP 96540–1000, Building 3190, Sumay Drive, Santa Rita, Guam 96915; phone (671) 339–2115; e-mail at: *donnell.evans@guam.navy.mil*.

SUPPLEMENTARY INFORMATION: The Commander Naval Forces Marianas (COMNAVMAR) as the Department of Defense Representative Guam, Commonwealth of the Northern Mariana Islands, Federated States of Micronesia and Republic of Palau is the Executive Agent for the Commander United States Pacific Command (USPACOM) on all matters of MIRC management and sustainment. COMNAVMAR coordinates Joint Service planning and use of MIRC ranges and training areas. COMNAVMAR's role is to provide resources, range complex management, and training support to U.S. military forces in the Western Pacific (WESTPAC) Theater.

COMNAVMAR's mission in the MIRC is to support Army, Navy, Marine Corps, Air Force, U.S. Coast Guard, Army Reserves, and Guam National Guard tactical training by maintaining and operating facilities and range infrastructure and by providing services and material. The MIRC consists of multiple ranges and training areas of land, sea space (nearshore and offshore), undersea space, and air space under different controlling authorities in the Territory of Guam, the Commonwealth of the Northern Mariana Islands (CNMI), and surrounding waters.

The mission of USPACOM is to provide interoperable, trained, and combat-ready military forces to support the National Security Strategy of the United States in the WESTPAC Theater. United States military forces from all Services use the MIRC as a training venue to prepare for contingency warfare.

The MIRC is the westernmost military training complex in U.S. territory. The MIRC has range and training area assets in Guam and the Northern Mariana Islands archipelago. Guam is located roughly three quarters the distance from Hawaii to the Philippines, 1,600 miles east of Manila and 1,550 miles southeast of Tokyo. The southern extent of CNMI is located 40 miles north of Guam (Rota Island) and extends 330 miles to the northwest. The CNMI capital, Saipan, is 3,300 miles west of Honolulu and 1,470 miles south-southeast of Tokyo. The location of the MIRC allows for training of U.S. military forces in WESTPAC, without having to return to Hawaii or the continental United States.

The purpose of the Proposed Action is to: Achieve and maintain military readiness using the MIRC to conduct and support current, emerging, and future military training and RDT&E operations on existing DoD lands and ranges and adjacent air and ocean areas; and, upgrade and modernize range complex capabilities to enhance and sustain military training and RDT&E operations and to expand the Services warfare missions.

The Proposed Action stems from the need to: (1) Maintain current levels of military readiness by training in the MIRC; (2) accommodate future increases in operational training tempo on existing ranges and adjacent air and ocean areas in the MIRC and support the rapid deployment of military units and strike groups; (3) achieve and sustain readiness so that the Military Services can quickly surge required combat power in the event of a national crisis or contingency operation consistent with Service training requirements; (4) support the acquisition, testing, training, and fielding of advanced platforms and weapons systems into Service force structure; and, (5) maintain the long-term viability of the MIRC while protecting human health and the environment, enhancing the quality of training, communications, and safety within the range complex.

The EIS/OEIS will consider two action alternatives to accomplish these objectives, in addition to the No-Action Alternative. The No-Action Alternative is the continuation of training operations, RDT&E activities and on-going base operations. This includes all multi-Service training activities and operations on Navy and Non-Navy ranges and training areas including: Andersen Air Force Base (Main Base, Northwest Field, Andersen South, and Tarague Beach); Naval Station Guam and its off-shore areas; Farallon de Medinilla; Tinian; Saipan; and Air Traffic Control Assigned Airspace (ATCAA). Alternative 1 includes the activities described in the No-Action Alternative with the addition of increased training operations as a result of upgrades and modernization of existing ranges and training areas, and of operations on existing ranges that are required to support the relocation of military units to the DoD REP Area of Responsibility (AOR). Alternative 2 would include all the operations described in Alternative 1 with the addition of new operations on existing ranges and training areas and adjacent air and ocean areas with upgraded and modernized capabilities. In addition, Alternative 2 would incorporate the increased operations resulting from increased operational tempo and training event frequency to optimize training throughput in support of current and future contingencies.

Previously, the Navy's Joint Guam Program Office (JGPO) published a Notice of Intent to prepare an EIS/OEIS for the Relocation of U.S. Marine Corps Forces to Guam (**Federal Register**, 72 FR 10186, March 7, 2007). JGPO's proposed EIS/OEIS will examine potential impact from activities associated with the Marine Corps units' relocation from Okinawa, Japan to Guam, including operations, infrastructure changes and training. Since the proposed MIRC EIS/OEIS will cover all DoD training on existing DoD land and operating areas in and around Guam and CNMI, there will be some overlap between the two proposed EIS/OEISs. Therefore, preparation of these documents will be closely coordinated to ensure consistency.

Environmental issues that will be addressed in the EIS/OEIS include but are not limited to: Airspace; biological resources (including marine mammals and threatened and endangered species); cultural resources; health and safety; and noise. The analysis will include an evaluation of direct and indirect impacts, and will account for cumulative impacts.

The DoD REP is initiating the scoping process to identify community concerns and issues that must be addressed in the EIS/OEIS. Federal agencies, Government of Guam and CNMI agencies, the public, and other interested stakeholders are encouraged to provide oral and written comments to the Navy to identify specific issues or topics of concern for consideration in the EIS/OEIS. The DoD REP will hold three public scoping meetings. Each meeting will consist of an informal information session, staffed by Navy representatives. Members of the public can contribute oral or written comments at the scoping meetings or subsequent to the meetings by mail, fax, or e-mail. All comments, oral and written, will receive the same consideration during EIS/OEIS preparation. Written comments on the scope of the EIS/OEIS must be postmarked by July 16, 2007, and should be mailed to: MIRC TAP EIS, 258 Makalapa Drive, Suite 100, Pearl Harbor, HI 96860–3134, *Attention:* EV2. Comments can be faxed to 808–474–5419 or e-mailed to *marianas.tap.eis@navy.mil.*

Dated: May 24, 2007.

L.R. Almand,

Office of the Judge Advocate General, U.S. Navy, Federal Register Liaison Officer.

[FR Doc. E7–10629 Filed 5–31–07; 8:45 am]

BILLING CODE 3810–FF–P

DEPARTMENT OF DEFENSE

Office of the Secretary

Revised Non-Foreign Overseas Per Diem Rates

AGENCY: DoD, Per Diem, Travel and Transportation Allowance Committee.

ACTION: Notice of revised non-foreign overseas per diem rates.

SUMMARY: The Per Diem, Travel and Transportation Allowance Committee is publishing Civilian Personnel Per Diem Bulletin Number 253. This bulletin lists revisions in the per diem rates prescribed for U.S. Government employees for official travel in Alaska, Hawaii, Puerto Rico, the Northern Mariana Islands and Possessions of the United States. AEA changes announced in Bulletin Number 194 remain in effect. Bulletin Number 253 is being published in the **Federal Register** to assure that travelers are paid per diem at the most current rates.

DATES: *Effective Date:* June 1, 2007.

SUPPLEMENTARY INFORMATION: This document gives notice of revisions in per diem rates prescribed by the Per Diem Travel and Transportation Allowance Committee for non-foreign areas outside the continental United States. It supersedes Civilian Personnel Per Diem Bulletin Number 252. Distribution of Civilian Personnel Per Diem Bulletins by mail was discontinued. Per Diem Bulletins published periodically in the **Federal Register** now constitute the only notification of revisions in per diem rates to agencies and establishments outside the Department of Defense. For more information or questions about per diem rates, please contact your local travel office. The text of the Bulletin follows:

Dated: May 24, 2007.

C.R. Choate,

Alternate OSD Federal Register Liaison Officer, DoD.

BILLING CODE 5001–06–M

This Page Intentionally Left Blank

APPENDIX C

AGENCY COORESPONDENCE

This Page Intentionally Left Blank

DEPARTMENT OF THE NAVY
NAVAL FACILITIES ENGINEERING COMMAND, PACIFIC
258 MAKALAPA DR., STE. 100
PEARL HARBOR, HAWAII 96860-3134

5090.1G03
Ser EV22/ 237
26 MAR 2008

Mr. Patrick Leonard, Field Supervisor
Pacific Islands Fish and Wildlife Office
U.S. Fish and Wildlife Service
300 Ala Moana Boulevard, Room 3-122, Box 50088
Honolulu, Hawaii 96850

Dear Mr. Leonard:

SUBJECT: REQUEST FOR COMMENCEMENT OF SECTION 7, ENDANGERED SPECIES ACT, INFORMAL CONSULTATION REGARDING PROPOSED ACTIONS IN GUAM AND THE COMMONWEALTH OF THE NORTHERN MARIANA ISLANDS

As part of the National Environmental Policy Act process, the Department of the Navy is developing a series of documents and studies considering the possible impacts to species of plants and animals protected by the Endangered Species Act (ESA) which may result from the proposed establishment and operation of the Mariana Islands Range Complex (MIRC) and the relocation of U.S. Marine Corps forces to Guam. Over the past year, we have worked with members of your staff to develop a list of such species and discuss the range of potential impacts, possible design and operational modifications that may reduce adverse impacts, and other related topics, and we thank you for your assistance.

The purpose of this letter is to establish a date-of-record for commencement of informal ESA Section 7 consultation as directed by 50 CFR 402.12 (c). While informal consultation technically began months ago during our conversations and meetings, this letter provides a date-certain for documentation purposes for both of our agencies. This letter also confirms agreement of the attached species list that we created together and received on February 12, 2008.

Biological Assessments are in preparation for the two actions and drafts will be provided for your review when completed. We will continue to work closely at the staff level and appreciate your assistance on these very challenging projects.

Sincerely,

KAREN SUMIDA
Business Line Manager
Environmental
Acting

5090.1G03
Ser EV22/ 237
2 6 MAR 2008

Enclosure: Federally listed, candidate, and delisted species in the Territory of Guam and Commonwealth of the Northern Mariana Islands

Copy to:
Joint Guam Program Office (JGPO, Ms. Theresa Bernhard)
COMPACFLT (N01CE1, Mr. Larry Foster)
Guam Department of Agriculture (Mr. Paul Bassler)

Federally listed, candidate, and delisted species in the Territory of Guam and Commonwealth of the Northern Mariana Islands.

Species	Protection Status[1]	Territory of Guam	Commonwealth of the Northern Mariana Islands														Citations
			Rota	Aguiguan	Tinian	Saipan	Farallon de Medinilla	Anatahan	Sarigan	Guguan	Alamagan	Pagan	Agrihan	Asuncion	Maug	Uracus	
Mariana Fruit Bat (*Pteropus mariannus*)	T	< 100 (2007)[a]	> 800 (1983)	< 10 (1983)	< 25 (1983)	< 50 (1983)		< ? (2007)	200 (2000)	350 (2000)	200 (2000)	1,500 (2000)	1,000 (2000)	400 (1983)	< 25 (1983)		Wiles et al. 1989, Cruz et al. 2000a-e, C. Kessler, pers. comm. 2007
Little Mariana Fruit Bat (*Pteropus tokudae*)	E	PEX															USFWS 2004
Sheath-tailed Bat (*Emballonura semicaudata*)	C	EX	EX	< 500 (2003)	EX	EX											Esselstyn et al 2004
Nightingale Reed-warbler (*Acrocephalus luscinia*)	E	EX		PEX	EX	4,200 (1997)					173 (2000)	PEX					USFWS 1998a, Cruz et al. 2000c
Mariana Swiftlet (*Aerodramus bartschi*)	E	> 800 (2006)	EX	> 400 (2002)	EX	5,000 (2005)											Esselstyn et al. 2002, Cruz et al 2007; A. Brooke pers. comm. 2006
Mariana Crow (*Corvus kubaryi*)	E	10 (2007)	80 pairs (2007)														J. Quitigua pers comm. 2007 Berry et al. 2007
Mariana Common Moorhen (*Gallinula chloropus*)	E	90 (2001)	2 (2001)		41 (2001)	154 (2001)						PEX					Takano and Haig 2004
Guam Micronesian Kingfisher (*Halcyon cinnamomina*)	E	CAP [95][b]															Bahner and Bier 2007
Micronesian Megapode (*Megapodius laperouse*)	E	EX	EX	< 80 (2002)	< 10 (1997)	< 25 (1997)	PEX	PEX	360 (2000)	305 (2000)	< 30 (1992)	134 (2000)	395 (2000)	< 25 (1992)	< 150 (1992)	PEX	USFWS 1998b, Cruz et al. 2000a-e
Guam Rail (*Gallirallus owstoni*)	E	CAP [?]	XP 60-80														P. Wenninger pers. comm. 2007, S. Medina pers. comm. 2007
Guam Bridled White-eye (*Zosterops conspicillatus*)	E	PE															USFWS 2004
Rota Bridled White-eye (*Zosterops rotensis*)	E		1,000 (1999)														Amidon 2000
Tinian Monarch (*Monarcha takatsukasae*)	D				56,000 (1996)												Lusk et al. 2000
Green Sea Turtle (*Chelonia mydas*)	T	NEST	NEST		NEST	NEST						UNK					Berger et al. 2005
Hawksbill Turtle (*Eretmochelys imbricate*)	E	NEST	UNK			UNK											Berger et al. 2005
Mariana Wandering Butterfly (*Vagrans egestina*)	C	PEX?	1 Pop. (1995)														Schreiner and Nafus 1996

Species	Protection Status[1]	Territory of Guam	Commonwealth of the Northern Mariana Islands														Citations
			Rota	Aguiguan	Tinian	Saipan	Farallon de Medinilla	Anatahan	Sarigan	Guguan	Alamagan	Pagan	Agrihan	Asuncion	Maug	Uracus	
Mariana Eight Spot Butterfly (*Hypolimnus oticula*)	C	10 Pop. (1995)				PEX?											Schreiner and Nafus 1996
Humped Tree Snail (*Partula gibba*)	C	> 600 (2006)	<1,600 (1996)	PEX?	PEX?	UNK		PEX?	>100k (2006)		UNK (1994)	UNK (1994)					B. Smith pers. comm. 2006, Bauman 1996, Kurozumi 1994
Langford's Tree Snail (*Partula langfordi*)	C			PEX?													B. Smith pers. comm. 2006
Guam Tree Snail (*Partula radiolata*)	C	22 Pop (2004)															B. Smith pers. comm. 2004
Fragile Tree Snail (*Samoana fragilis*)	C	4 Pop (2006)	1 Pop (1996)														B. Smith pers. comm. 2006, Bauman 1996
Nesogenes rotensis (No Common Name)	E		< 600 (2005)														USFWS 2006
Osmoxylon mariannense (No Common Name)	E		10 (2002)														USFWS 2006
Serianthes nelsonii (Hayun Lagu (Guam), Tronkon guafi (Rota))	E	1 (1992)	121 (1992)														Wiles et al. 1995, A. Brooke pers. comm. 2007

[1] **Federal Listing Status:** T = Threatened, E = Endangered, C = Candidate, and D = Delisted, Undergoing 5 Year Post-Delisting Monitoring
[2] **Population Status:** PEX = Presumed Extinct, UNK = Status Uncertain, CAP = Extirpated in the Wild, Captive Population Established, XP = Non-essential Experimental Population, and NEST = Nesting beaches
[a] Date of population estimate
[b] Population estimate

Migratory Bird Treaty Act, locally listed, IUCN, and other species of concern in the Territory of Guam and Commonwealth of the Northern Mariana Islands.

Species	Protection Status[1]	Territory of Guam	Commonwealth of the Northern Mariana Islands													
			Rota	Aguiguan	Tinian	Saipan	Farallon de Medinilla	Anatahan	Sarigan	Guguan	Alamagan	Pagan	Agrihan	Asuncion	Maug	Uracus
Wedge-tailed Shearwater (*Puffinus pacificus*)	M					X										
White-tailed Tropicbird (*Phaethon lepturus*)	M		X	X	X	X	X	U	X	X	X	X	X	X	X	
Red-tailed Tropicbird (*Phaethon rubricauda*)	M		X	X	X	X	X		X	X		X	X	X	X	X
Masked Booby (*Sula dactylatra*)	M					X	X	U		X					X	X
Brown Booby (*Sula leucogaster*)	M		X	X	X	X	X	U	X	X	X	X	X	X	X	X
Red-footed Booby (*Sula sula*)	M		X				X			X		X		X	X	
Great Frigatebird (Fregata minor)	M						X									
Little Tern (*Sterna albifrons*)	M					X										
Black-naped Tern (*Sterna sumatrana*)	M					U										
Spectacled Tern (*Sterna lunata*)	M					U		U	X	X						
Bridled Tern (*Sterna anaethetus*)	M						X									
Sooty Tern (*Sterna fuscata*)	M					X				X				X		X
Brown Noddy (*Anous stolidus*)	M	X	X	X	X	X	X	U	X	X	X	X	X	X	X	X
Black Noddy (*Anous minutus*)	M			X	X		X			X		X	X		X	
White Tern (*Gygis alba*)	M	X	X	X	X	X	X	X	X	X	X	X	X	X	X	

Species	Protection Status[1]	Territory of Guam	Commonwealth of the Northern Mariana Islands													
			Rota	Aguiguan	Tinian	Saipan	Farallon de Medinilla	Anatahan	Sarigan	Guguan	Alamagan	Pagan	Agrihan	Asuncion	Maug	Uracus
Yellow Bittern (*Ixobrychus exilis*)	M	X	X	X	X	X										
Pacific Reef Heron (*Ardea sacra*)	M	X	X	X	X	X	U		U	U	U	X	U	X	U	
White-throated Ground Dove (*Gallicolumba xanthonura*)	G,I,S		X	X	X	X	U		X	X	X	X	X	X		
Mariana Fruit Dove (*Ptilinopus roseicapilla*)	G,I,S		X	X	X	X										
Micronesian Starling (*Aplonis opaca*)	G.I,S	X	X	X	X	X	X	U	X	X	X	X	X	X	X	
Collared Kingfisher (*Halcyon chloris*)	S		X	X	X	X			X		X	X	X	X	X	
Tinian Monarch (*Monarcha takatsukasae*)	C,I				X											
Rufous Fantail (*Rhipidura rufifrons*)	G,S		X	X	X	X										
Micronesian Honeyeater (*Myzomela rubrata*)	G,S		X	X	X	X		?	X	X	X	X	X	X	X	
Bridled White-eye (*Zosterops conspicillatus*)	G,I,S			X	X	X										
Golden White-eye (*Cleptornis marchei*)	I,S			X		X										
Micronesian Gecko (*Perochirus ateles*)	G,C	X	X	?	X	X										
Oceanic Gecko (*Gehyra oceanica*)	G	X	X	X	X	X				X	X	?		X		
Pacific Slender-toed Gecko (*Nactus pelagicus*)	G	X	X		X	?					X	U				
Snake-eyed Skink (*Cryptoblepharus poecilopleurus*)	G	X	X	X	X	X	?	?	X	X	X	U	X	X	X	
Tide-pool Skink (*Emoia atrocostata*)	G		X							X	X	U				

Species	Protection Status[1]	Territory of Guam	Commonwealth of the Northern Mariana Islands													
			Rota	Aguiguan	Tinian	Saipan	Farallon de Medinilla	Anatahan	Sarigan	Guguan	Alamagan	Pagan	Agrihan	Asuncion	Maug	Uracus
Azure-tailed Skink (*Emoia cyanura*)	G	U														
Slevin's Skink (*Emoia slevini*)	G	X	X		X				X		X	U		X		
Moth Skink (*Lipinia noctua*)	G	X	U													
No Common Name (*Succinea guamensis*)	S	X														
No Common Name (*Succinea piratarum*)	I,S	X														
No Common Name (*Succinea quadrasi*)	I,S	X														
Coconut Crab (*Birgus latero*)	S	X	X	X	X	X	X	X	X	X	X	X	X	X	X	
Heritiera longipetiolata (Ufa-halomtano)	I,S	X	X		X	X										
Aglaia mariannensis	I	X	X	X	X	X		X	X	X	X	X	X	X		
Cyathea lunulata (Tsatsa)	G	X														
Lycopodium phlegmaria var. *logifolium* (Disciplina Fern)	C	X	X													

[1] **Protection Status:** M = Migratory Bird Treaty Act, I = IUCN Listed VU to CR, C = CNMI Listed, G = Guam Listed, S = Species of Concern (FWS, CNMI)
[2] **Population Status:** X = Present, U = Unknown

United States Department of the Interior

FISH AND WILDLIFE SERVICE
Pacific Islands Fish and Wildlife Office
300 Ala Moana Boulevard, Room 3-122, Box 50088
Honolulu, Hawaii 96850

In Reply Refer To:
2007-I-0347

MAY 0 2 2008

Ms. Karen Sumida
Department of the Navy
Naval Facilities Engineering Command, Pacific
258 Makalapa Drive, Suite 100
Pearl Harbor, Hawaii 96860

Subject: Informal Consultation Request for the Proposed Establishment and Operation of the Mariana Islands Range Complex and for the Relocation of the U.S. Marine Corps Forces to Guam

Dear Ms. Sumida:

Thank you for your March 26, 2008, letter requesting agreement with the species list prepared for the proposed establishment and operation of the Mariana Islands Range Complex (MIRC) and for the relocation of the U.S. Marine Corps forces to Guam via the Joint Guam Program Office (JGPO). Your letter also requested to establish a date-of-record for the commencement of informal consultation under section 7 of the Endangered Species Act of 1973 (16 U.S.C. 1531 et seq.), as amended (Act) for U.S. Navy actions associated with MIRC and JGPO. We received your letter on March 28, 2008. On April 21, 2008, you agreed to an extension of our deadline.

As you mention in your letter, we began informal discussions regarding MIRC and JPGO in 2007. We have compiled a list of meetings and conversations that have occurred over the past year where we received any information or any discussion of endangered or threatened species that may be affected by MIRC or JGPO. We request that you verify this list and add any conversations, electronic mailings, and/or meetings that we may have inadvertently left off the coordination history (see Table 1 and Table 2) for either MIRC or JGPO.

We reviewed the species list you provided and we concur that the species on the list are the federally listed, candidate, delisted, and migratory bird species known to use the terrestrial resources from Guam and the Commonwealth of the Northern Mariana Islands (CNMI). The population numbers provided within these tables should be viewed with caution as some of the data are older and some data are currently in revision. For example, a recent survey (2007) for the nightingale reed-warbler on Saipan estimated the population size at 2,596 pairs (Camp et al., *in prep.*) instead of 4,200 pairs as reported from 1997. Additionally, the tables enclosed within your letter only include species and do not include critical habitat. Therefore, we have enclosed a list of terrestrial critical habitat (see Table 3).

There are many sites within Guam and CNMI that have other protected habitats that are not designated as critical habitat. U.S. Navy lands at the Communications Annex and the ordnance Annex and Andersen Air Force Base on Guam were excluded from the critical habitat designation due to their respective Integrated Natural Resources Management Plans, which include projects that could maintain or benefit the Mariana fruit bat (*Pteropus mariannus mariannus*), Mariana crow (*Corvus kubaryi*), and Guam Micronesian kingfisher (*Halcyon cinnamomina cinnamomina*). Though the U.S. Navy and U.S. Air Force lands were not included in the final critical habitat designation, these areas are essential for the conservation of these species and to meet their respective recovery goals. In 1994, the U.S. Navy and U.S. Air Force entered into cooperative agreements with the Service to create the Guam National Wildlife Refuge Overlay on U.S Navy and U.S. Air Force lands on Guam. This agreement established that the U.S. Navy and the U.S. Air Force will coordinate with the Service regarding Federal activities which may affect these areas even if they are currently unoccupied by the species. In addition, there are areas that were not designated as critical habitat but are essential to the survival and recovery of listed species outside U.S. Navy and U.S. Air Force lands on Guam that may be affected by the proposed action. Approximately 936 acres (379 hectares) of land was preserved on Tinian, for the protection of the Tinian monarch, as a conservation measure within the Federal Aviation Administration's project description for improvements to the Tinian International Airport. Also, several wetlands have been restored, enhanced, or created as mitigation under the U.S. Army Corps of Engineers authority under the Clean Water Act. Many of these wetlands are important for listed species including the Mariana common moorhen and the nightingale reed-warbler. At this time we do not have a comprehensive list of all locations and habitats that have been set aside or receive protection from other local and Federal agencies.

We recommend that you coordinate directly with Guam Division of Aquatic and Wildlife Resources, CNMI Division of Fish and Wildlife, and National Marine Fisheries Service to ensure that the species lists adequately reflect trust resources protected under their respective jurisdictions. We also recommend that you contact these and other appropriate agencies regarding critical habitat, essential habitat, or habitats with local protections.

The purpose of informal consultation is to: clarify whether the action area has listed, proposed, and candidate species or designated critical habitat; determine the potential effects of the proposed action on these species or critical habitats; explore ways to modify the proposed action to reduce or remove adverse affects to the species or critical habitats; determine the need to enter into formal consultation or conference; and to explore the design or modification of an action to benefit the species or critical habitat. Although we have been coordinating for over a year, we are concerned that the Service and the Navy have not spent a sufficient amount of time discussing actions associated with the MIRC or JGPO and their potential affect to listed species and their habitats. We recommend that prior to completion of your biological assessment, a series of informal meetings be conducted to update species status and critical habitat information and to explore ways to avoid and minimize impacts to these species and their habitats.

We look forward to working with you regarding the two proposed projects. If you have questions regarding federally protected species, critical habitat, or this letter, please contact Holly Herod, Fish and Wildlife Biologist for Technical Assistance and Consultation at (808)792-9400.

Sincerely,

for Patrick Leonard
Field Supervisor

cc:
Tino Aguon, Guam Division of Aquatic and Wildlife Resources, Guam
Chris Bandy, U.S. Fish and Wildlife Service, Guam
Paul Bassler, Guam Department of Agriculture, Guam
Theresa Bernhard, Joint Guam Program Office, Washington DC
Lisa Fiedler, Joint Guam Program Office, Guam
Larry Foster, COMPACFLT (N01CE1), Hawaii
Sylvan Igisomar, CNMI Division of Fish and Wildlife Resources, Saipan
Ed Lynch, KAYA, Contractor to Navy Commander Pacific Fleet

Enclosures

Table 1. Coordination history regarding the proposed establishment and operation of the Mariana Islands Range Complex.

June 8, 2007. The Service received a letter dated June 1, 2007, from the Navy. The letter included a copy of a Federal Register document announcing the Notice of Intent for MIRC and public scoping meetings. The letter requested our input in identifying the scope of issues and significant issues related to MIRC.

July 11, 2007. Department of Defense (DOD) held a Quarterly meeting with participating agencies including the Service. DOD indicated that: scoping meetings are complete for MIRC; a timeline for NEPA was provided; MIRC covers existing training in existing training areas only; new training or new areas would be covered by JGPO.

July 23, 2007. The Service received a copy of a letter dated July 16, 2007, from the U.S. Environmental Protection Agency regarding their comments related to the MIRC scoping comments.

July 30, 2007. The Service sent a letter to the MIRC office providing comments on the NOI to develop and EIS/OEIS for MIRC.

September 21, 2007. The Service had a meeting with the Navy and its representatives regarding MIRC, JGPO, and the brown treesnake. We suggested one section 7 consultation to combine both MIRC and JGPO actions as the actions are all interrelated and interdependent. We further indicated that a thorough biological assessment would be needed for MIRC and JGPO.

September 24, 2007. The Service had a meeting with the Navy regarding JGPO and MIRC actions, improving cross agency communication, and surveys for species that may be impacted by the proposed actions. We indicated that migratory birds should be considered in the NEPA documents if large towers are going to be built.

October 4 – 5, 2007. The Service attended the JGPO partnering session on Guam and received JGPO related hard copy presentations. We received a hard copy of the presentation given by Ed Lynch, Navy contractor, regarding the MIRC EIS/OEIS.

November 7, 2007. DOD held a Quarterly meeting with the participating agencies including the Service. DOD indicated that the terrestrial biological assessment for MIRC was 50% complete; the JGPO DEIS was due out January 2009 and currently only Guam information was known.

November 14 – 16, 2007. The Service attended the Brown Treesnake (BTS) Working Group meeting held on Saipan. A review of JGPO and MIRC was provided by Captain Robert Lee (Navy) and Ed Lynch (Navy contractor), respectively. Earl Campbell (Service) provided an update and lead a discussion regarding the efforts that will be needed by the Navy to prevent the spread of BTS from the implementation of JGPO and MIRC.

February 14 – 15, 2008. The Service attended the JGPO partnering session on Guam. An update on MIRC was presented to participants.

March 7, 2008. Vanessa Pepi (Navy) and Patrice Ashfield (Service) met to discuss the MIRC DOPPA and Biological Assessment. Ms. Ashfield mentioned Service concerns regarding increased training at Farallon de Medinilla and the potential impacts to the Micronesian megapode, the listing of the Mariana fruit bat throughout its range, and potential impacts to sea turtles and their nesting beaches.

March 28, 2008. The Service received a letter dated March 26, 2008, from the Navy. The letter included an attached species list and requested: official commencement of informal consultation and concurrence with the attached species list for MIRC and JGPO.

April 16 – 18, 2008. Service attended the BTS Conference held in Honolulu, HI. The conference provided an update on JGPO and MIRC and focused on status of current research and invasive species issues associated with JGPO and MIRC.

Table 2. Coordination history regarding the proposed relocation of the U.S. Marine Corps forces to Guam (JGPO).

May 17, 2007. The Navy sent a letter to Mr. Dale Hall (Service) requesting that the Service be a cooperating agency in the JGPO NEPA process. This letter was provided by copy at the June 4 – 5, 2007 JGPO Partnering Session.

May 18, 2007. Dwayne Minton (Service – Ecological Services) and Chris Bandy (Service – Refuges) emailed Captain Robert Lee (Navy) the Service's comments regarding the March 7, 2007, Notice of Intent to develop an EIS/OEIS for the relocation of the U.S. Marine Corps Forces to Guam.

June 4 – 5, 2007. The Service attended the JGPO Partnering Session.

June 11, 2007. Vanessa Pepi (Navy) provided the Service with a copy of the Scope of Work and Survey Methods for the biological surveys that will occur on Guam.

July 3, 2007. The Service sent a letter to Commander Hinton (Navy) regarding cooperating agency status for the development of the JGPO EIS/OEIS.

July 7, 2007. Earl Campbell (Service) emailed a summary of a phone conversation with Vanessa Pepi (Navy) regarding: potential areas in the CNMI where JGPO activities may occur; need to discuss conservation areas and strategies early, internal meetings, and a letter for NEPA cooperating agency status.

July 11, 2007. Department of Defense (DOD) held a Quarterly meeting with participating agencies including the Service. DOD indicated that: scoping meetings are complete for MIRC; a timeline for NEPA was provided; MIRC covers existing training in existing training areas only; new training or new areas would be covered by JGPO.

July 18, 2007. Earl Campbell (Service) emailed Mr. Bice, Mr. Lee, and Mr. Schregardus (Navy) a request for staff and financial support needed for brown treesnake interdiction, control, and research efforts associated with JGPO activities. The email also included a report from OMB.

July 31, 2007. The Service sent a letter to the JGPO office requesting assistance related to the increase in Service expected workload related to JGPO.

August 15, 2007. The Service had a meeting with the Navy to discuss terrestrial biological information needs for JGPO. We indicated that consultation needs to remain informal until all the information necessary to complete a formal consultation is prepared and finalized. We further requested that surveys should be completed for any species that may be impacted and that the surveys should consider the full extent of the range or status for these species.

September 21, 2007. The Service had a meeting with the Navy and its representatives regarding MIRC, JGPO, and the brown treesnake. We suggested one section 7 consultation to combine both MIRC and JGPO actions as the actions are all interrelated and interdependent. We further indicated that a thorough biological assessment would be needed for MIRC and JGPO.

September 24, 2007. The Service had a meeting with the Navy regarding JGPO and MIRC actions, improving cross agency communication, and surveys for species that may be impacted by the proposed actions. We indicated that migratory birds should be considered in the NEPA documents if large towers are going to be built.

October 4 – 5, 2007. The Service attended the JGPO partnering session on Guam and received JGPO related hard copy presentations. We received a hard copy of the presentation given by Ed Lynch, Navy contractor, regarding the MIRC EIS/OEIS.

November 7, 2007. DOD held a Quarterly meeting with the participating agencies including the Service. DOD indicated that the terrestrial biological assessment for MIRC was 50% complete; the JGPO DEIS was due out January 2009 and currently only Guam information was known.

November 14 – 16, 2007. The Service attended the Brown Treesnake (BTS) Working Group meeting held on Saipan. A review of JGPO and MIRC was provided by Captain Robert Lee (Navy) and Ed Lynch (Navy contractor), respectively. Earl Campbell (Service) provided an update and lead a discussion regarding the efforts that will be needed by the Navy to prevent the spread of BTS from the implementation of JGPO and MIRC.

November 19, 2007. The Service emailed unofficial species lists for Guam and CNMI and resource lists for specific locations on Guam to Ed Lynch (Navy contractor), Teresa Bernhard (JGPO) and Lisa Fiedler (JGPO).

November 19, 2007. Earl Campbell (Service) participated in "The Department of Interior Interagency Group on Insular Affairs, Guam Interagency Task Force Meeting" and presented brown treesnake needs related to JGPO to the Natural Resources sub-Committee.

December 17, 2007. The Service met with the Navy regarding potential species surveys in the CNMI. We also provided information on the data needs for section 7 consultations as compared with the data needed for a programmatic NEPA document.

January 22, 2008. Earl Campbell (Service) provided a briefing to the Service, U.S. Marine Corps, and U.S. Army related to brown treesnake and JGPO activities.

January 23, 2008. Earl Campbell (Service) provided a briefing to Assistant Secretary of the Navy regarding brown treesnake and JGPO activities.

January 23, 2008. The Service attended a video teleconference regarding the upcoming JGPO Partnering Session meeting.

January 25, 2008. Earl Campbell (Service) provided an overview of the brown treesnake issues related to JGPO to the Service and Department of Defense.

January 29, 2008. Vanessa Pepi (Navy) emailed Dwayne Minton and Curt Kessler (Service) maps depicting the JGPO training concept plan for Tinian.

February 4, 2008. Stephen Smith (Navy) emailed Dwayne Minton, Curt Kessler, Kevin Foster, Michael Molina (Service) maps depicting the JGPO training concept study on Guam and CNMI.

February 14 – 15, 2008. The Service attended the JGPO partnering session on Guam.

February 19, 2008. Rick Spaulding (Navy contractor) emailed Nate Hawley, Earl Campbell, Holly Herod, and Dwayne Minton (Service) the Pre-Final Sampling Plan for the natural resource surveys to support JGPO on Guam.

March 27, 2008. The Navy emailed an initial monthly update related to the JGPO EIS.

March 28, 2008. The Service received a letter dated March 26, 2008, from the Navy. The letter included an attached species list and requested: official commencement of informal consultation and concurrence with the attached species list for MIRC and JGPO.

April 14, 2008. The Marines hosted a workshop to familiarize participants with the potential impacts from terrestrial training.

April 15, 2008. The Service hosted a workshop to familiarize participants with other DOD conservation strategies and to brainstorm conservation strategies that may be useful for implementation by JGPO.

April 16 – 18, 2008. Service attended the BTS Conference held in Honolulu, HI. The conference provided an update on JGPO and MIRC and focused on status of current research and invasive species issues associated with JGPO and MIRC.

Table 3. Designated critical habitat within Guam and the Commonwealth of the Northern Mariana Islands. DOD lands within the Guam National Wildlife Refuge (NWR) Overlay Refuge lands are not included in the totals below as they are not designated as critical habitat. However, the lands within the Guam NWR Overlay Refuge are essential to the recovery of several listed species and DOD is required to coordinate with us when projects may affect lands within Guam NWR Overlay Refuge, even when these lands are unoccupied.

Critical Habitat	Location	Area
Mariana fruit bat	Unit A: Guam NWR, fee simple area	376 acres (152 hectares)
Mariana crow	Unit A: Guam NWR, fee simple area	376 acres (152 hectares)
	Unit B: Rota – Subunit 1	5,668 acres (2,294 hectares)
	Unit B: Rota – Subunit 2	365 acres (148 hectares)
Guam Micronesian kingfisher	Unit A: Guam NWR, fee simple area	376 acres (152 hectares)
Rota bridled white-eye	Rota	3,958 acres (1,602 hectares)

DEPARTMENT OF THE NAVY
COMMANDER
UNITED STATES PACIFIC FLEET
250 MAKALAPA DRIVE
PEARL HARBOR, HAWAII 96860-3131

IN REPLY REFER TO:
5090
Ser N01CE1/0353
3 Apr 08

Ms. Angela Somma
Chief, Endangered Species Division
National Marine Fisheries Service (NMFS)
National Oceanic and Atmospheric Administration
1315 East-West Highway, 13th Floor
Silver Spring, Maryland 20910-3282

Dear Ms. Somma:

SUBJECT: REQUEST FOR CONCURRENCE/REVISION ON SPECIES LIST, TECHNICAL ASSISTANCE FOR BIOLOGICAL ASSESSMENT PREPARATION

The Commander, U.S. Pacific Fleet (COMPACFLT), acting as executive agent for the Department of Defense (DoD) is preparing an Environmental Impact Statement (EIS)/Overseas EIS (OEIS) to assess the potential environmental impacts associated with sustainable range usage and enhancements within the Mariana Islands Range Complex (MIRC).

The Proposed Action is to sustain, upgrade, modernize, and transform the ranges and training areas within the MIRC and will implement the US Pacific Command's strategic vision for the range complex. The purpose of the proposed action is to achieve and maintain military readiness using the MIRC to support current and future training requirements and Research, Development, Training and Evaluation (RDT&E) efforts within the DoD ranges and training areas. The area of the MIRC includes approximately 450,187 square nautical miles of ocean (Enclosure 1).

A Biological Assessment (BA) will be prepared in support of the MIRC EIS/OEIS. Although the activities of the Proposed Action do not constitute a major construction activity as defined by the Endangered Species Act, the BA will be prepared in accordance with 50 CFR 402.12(f). This letter includes a list of threatened and endangered species determined to have potential occurrence within, or near, the action areas relevant to the Proposed Action (Enclosure 2). Critical habitat for some species has been defined, but none of the critical habitats include the Mariana Islands or Guam, and, therefore, critical habitat descriptions are not included here. Primary sources include various marine resource studies relevant to specific range areas.

Other action areas may have species under the mandate of the U.S. Fish and Wildlife Service (USFWS). A separate BA addressing the effects of the Proposed Action on terrestrial species will be submitted to the USFWS Pacific Islands Fish and Wildlife Office.

As per 50 CFR 402.12 (c), the Navy is requesting concurrence on **the** list of species, as well as possible revisions to the list NMFS deems relevant. If the BA is not commenced after 90 days from receipt of a species/critical habitat list, the Navy will verify the species list with NMFS (as per 50 FR 402.12 (e)).

We appreciate your continued support in helping us to meet our Section 7 responsibilities. My point of contact for this matter is **Ms.** Julie Rivers at (808) 472-1407 or julie.rivers@navy.mil

Sincerely,

J. P. RIOS
Captain, U.S. Navy
Deputy Fleet Civil Engineer
By direction

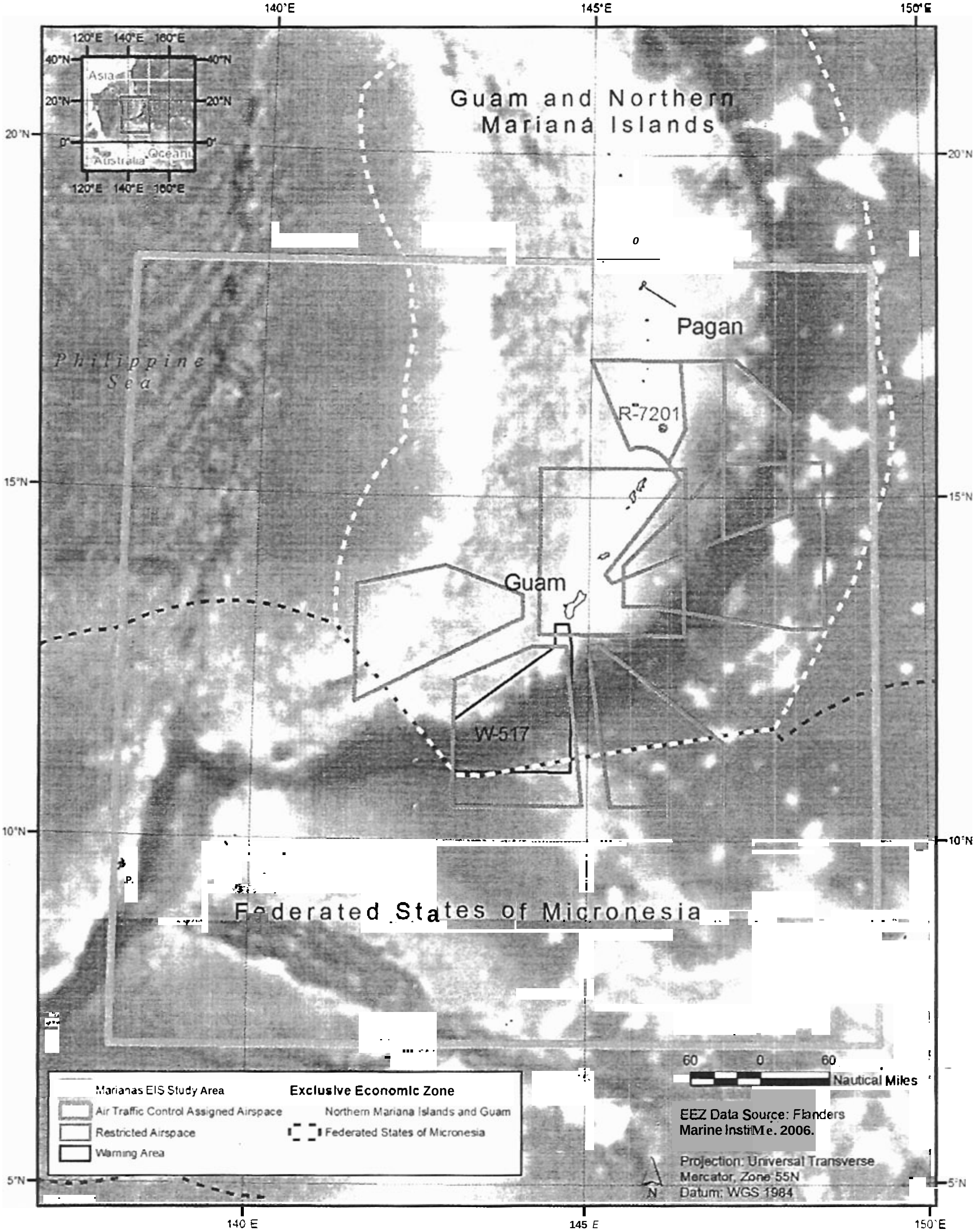
Enclosures:
(1) Map of the MIRC Study Area
(2) Marine Species Lists within the Mariana Islands

Copy to (w/ enclosures):
NMFS Pacific Islands Regional Office
USFWS Pacific Islands Fish and Wildlife Office

SUBJECT: REQUEST FOR CONCURRENCE/REVISION ON SPECIES LIST, TECHNICAL ASSISTANCE FOR BIOLOGICAL ASSESSMENT PREPARATION

Copy to (w/o enclosures):
OPNAV N45
Commander, Navy Region Marianas
Naval Facilities Engineering Command, Pacific (EV)
Naval Facilities Engineering Command, Marianas (EV)

Enclosure (1)
Map MIRC Study Area



ENCLOSURE 2 – Marine Species Identified for Section 7 Consultation with NOAA Fisheries Service

Scientific Name	English Name(s)	Chamorro/ Carolinian Name(s)	Federal Listing Status	Pacific Basin Habitat(s) [1]	Mariana Islands Sighting Records [2]
Marine Mammals					
Megaptera novaeangliae	Humpback whale		Endangered	Antarctic pelagic, in summer: temperate to subtropical. In winter: tropical coastal	(1) Stories of sightings and killings of nine whales in one season were recorded in the southern Mariana Islands (Beane 1905). (2) Two whales were reported about 100 m off the reef margin at Uruno Point on February 25, 1978 (Eads, personal communication cited in GovGuam 2005). (3) Three were sighted off the west coast of Guam on February 13, 1991 (Eads 1991). (4) A group of three was photographed off Saipan in February 1991 (Darling and Mori 1991). (5) A mother and calf werg sighted off the east coast of Rota in late February 1991. (Stinson, personal communication cited in GovGuam 2005). (6) A group of six or more was photographed at the entrance to Apra Harbor in January 1996 (1996 Anonymous citation, as cited in GovGuam 2005). (7) One visual sighting of several animals in waters off the coast of Saipan and Tinian on February 18, 2007. Six acoustic detections from towed array and 2 sonobuoy detections In waters of Guam and CNMI between February 6 –April 13, 2007 (DoN 2007).
Balaenoptera borealis	Sei whale		Endangered	Oceanic, warm water breeding, cold water feeding grounds between 40 degs North and 20 degree isotherm.	(1) A single specimen was sighted west of Saipan (Masaki 1972). (2) Two tagged sei whales from the Northern Mariana Islands were later killed several hundred kilometers south of the western Aleutian Islands (Horwood 1987) (3) Sixteen total visual sightings; five acoustic detections from towed array and two sonobuoy detections in waters of Guam and CNMI between January 13 – April 13, 2007 (DoN 2007).

Scientific Name	English Name(s)	Chamorro/ Carolinian Name(s)	Federal Listing Status	Pacific Basin Habitat(s) [1]	Mariana Islands Sighting Records [2]
Physeter macrocephalus	Sperm whale		Endangered	Pelagic, offshore, deep water, temperate – tropical.	(1) Sightings throughout the year between 1761 and 1920, especially around the Marianas, Pohnpei, and Kosrae (Townsend 1935) (2) One 15-m albino sperm whale was found beached at Acho Bay, Inarajan, Guam on September 5,1962 (Bordallo 1962). (3) One stranding reported (Kami and Lujan 1976). (4) Eight sperm whales were sighted June 15, 2001, including a young calf with a trailing umbilical cord (as cited In GovGuam 2005). (5) Twenty-three total visual sightings; 60 acoustic detections from towed array and six detections from sonobuoy between January 13 – April 13, 2007 in waters of Guam and CNMI; (DoN 2007). [4]
Balaenoptea physalus	Fin whale		Endangered	In the northern hemisphere, most migrate seasonally from high Arctic feeding areas In summer to low latitude breeding and calving areas in winter.	Rare occurrences possible in the action area (NOAA Fisheries Biological Qpinion, Valiant Shield Training Exercises. 2007).
Balaenoptera musculus	Blue whale		Endangered	Mainly pelagic; generally prefers cold waters and open seas, but young are born In warmer waters of lower latitudes.	Rare occurrences possible in the actlon area (NOAA Fisheries Biological Opinion, Valiant Shield Training Exercises. 2007).
Sea Turtles					
Chelonia mydas	Green sea turtle	Haggan bed'di / Wong mool	Threatened	Oceanic beaches and coastal strand (for nesting), convergence zones in the open ocean, and benthic feeding grounds in coastal areas.	Known to occur in / around Mariana Islands. Nest site locatlons on Andersen AFB (Explosive Ordnance Disposal Beach) and Guam NWR.
Dermochelys coriacea	Leatherback sea turtle	Hagan tasi / Wong raaw	Endangered	Oceanic beaches and coastal strand (for nesting), convergence zones in the open ocean, and benthic feeding grounds in coastal areas.	Known to occur in / around Mariana Islands
Caretta caretta	Loggerhead sea turtle	Hagan tasi / Wong	Threatened	Oceanic beaches and coastal strand (for nesting), convergence zones in the open ocean, and benthic feeding grounds in coastal areas.	Known to occur in / around Mariana Islands
Eretmochelys imbricata	Hawksbill sea turtle	Hagan karai / Wong maaw	Endangered	Oceanic beaches and coastal strand (for nesting), convergence zones in the open ocean, and benthic feeding grounds in coastal areas.	Known to occur in / around Mariana islands. Dead individual recovered off Talofofo (Jeff's Pirate Cove), southeast coast of Guam. One visual sighting on the fourth survey leg (DoN 2007).

Scientific Name	English Name(s)	Chamorro/ Carolinian Name(s)	Federal Listing Status	Pacific Basin Habitat(s) [1]	Mariana Islands Sighting Records [2]
Lepidochelys olivacea	Olive Ridley sea turtle		Threatened	Oceanic beaches and coastal strand (for nesting), convergence zones in the open ocean, and benthic feeding grounds in coastal areas.	One stuffed individual sighted in handicraft shop In Saipan in the 1970s (Kolinski, et al. 2001).
Fish Species					
Bolbometopon muricatum	Bumphead parrotfish		Species of Concern	Diurnal: barrier and fringing reefs 3 – 100 feet below surface. Nocturnal: shallow sandy lagoon flats Juveniles associated with seagrass beds Inside lagoons, adults associated with outer lagoons and seaward reefs. Spawning associated with lunar cycle near outer reef slope or near promontories, gutters, or channel mouths.	Nearly extirpated from Guam's reefs (NMFS 2007)
Cheilinus undulatus	Humphead wrasse		Species of Concern	Extremely patchy distribution with adults confined to steep outer reef slopes, channel slopes, and lagoon reefs In water 1- 100 meters deep.	Nearly extirpated from Guam's reefs (NMFS 2007)

1. Habitat sources from GovGuam DAWR (2005) and NOAA Fisheries Service factsheets for Bumphead parrotfish and Humphead wrasse (NMFS 2007).
2. Sighting records from GovGuam DAWR (2005) and Mariana islands Sea Turtle and Cetacean Survey Crulse Report (DoN 2007).

This Page Intentionally Left Blank

APPENDIX D

TRAINING OPERATIONS DESCRIPTIONS

This appendix describes in general detail the training operations conducted in the MIRC; however pre-event briefing material on specific hazards to training change frequently and necessarily reference updated briefs and instructions prepared by the scheduling authorities. Specific operator safety and environmental instructions for FDM, Guam and Tinian ranges, and all other training facilities are maintained current by the scheduling authorities. COMNAVMAR maintains COMNAVMARINST 3500.4, Marianas Training Handbook, whose purpose is to provide current safety and environmental information for training areas on Guam and CNMI, and COMNAVMARINST 3502.1, Standard Operating Procedures for R-7201 and FDM.

This Page Intentionally Left Blank

TABLE OF CONTENTS

APPENDIX D

TRAINING OPERATIONS DESCRIPTIONS

LIST OF FIGURES

There are no figures in this section.

LIST OF TABLES

This Page Intentionally Left Blank

MARIANAS RANGE COMPLEX TRAINING

In Chapter 2, Tables 2-1 through 2-5 list and describe the Mariana Islands Range Complex (MIRC) training areas and the typical training activity conducted in each area; Figures 2-1 through 2-10 show MIRC training area locations. Appendix D provides a description of typical training activities that have or may occur in the Mariana Islands Range Complex and further details the No Action, Alternative 1, and Alternative 2 activities.

Insertion/Extraction

Personnel approach or depart an objective area using various transportation methods and covert or overt tactics depending on the tactical situation. These operations train forces to insert and extract personnel and equipment day or night.

Table D-1: Insertion/Extraction

Range Activity	Platform	System or Ordnance	No Action Alternative	Alternative 1	Alternative 2	Location
SPECIAL WARFARE						
INSERTION/ EXTRACTION	SEAL Platoon/Squad; EOD Platoon/Squad; ARMY Platoon/Squad; USMC Platoon/Squad; USAF Platoon/Squad: RHIB; Small Craft; CRRC; H-60; H-46 or MV-22	Square Rig or Static Line; Fastrope; Rappel; SCUBA	104 Events; 2 to 8 hours.	150 Events; 2 to 8 hours.	150 Events; 2 to 8 hours.	PRI: Orote Pt. Airfield; Northwest Field; Orote Pt. Triple Spot; Apra Harbor; Gab Gab Beach SEC: Orote Pt. CQC; Finegayan DZ; Haputo Beach; Munitions Site Breacher House; Polaris Pt. Field; Orote Pt. KD Range

Special Warfare, NECC, or Army Personnel Parachute from Fixed-winged Aircraft

Basic Phase (Unit Level Training) Scenario

A fixed-winged aircraft such as a C-130 will fly to the objective area from a land based airfield. The embarked Special Warfare, Navy Expeditionary Combat Command (NECC), or other personnel will parachute (static line or free fall) into the planned area from either a high (25,000 ft or more) or a low (1,000 ft and below) altitude; training is conducted in any altitude between the two aforementioned altitudes.

Opposition force personnel may be employed as well as small arms with blanks or live ammunition (if permitted: live ammunition on MIRC land training areas is permitted only on small arms ranges or shoot houses). Ordnance, if used, typically includes 7.62 mm, 5.56 mm and .50 cal. These operations will vary in length depending on the transportation method and systems being used, typically from 2 to 8 hours.

Integrated and Sustainment Phase Training Scenarios

Typically do not differ from the Basic Phase Scenario.

Training Considerations

Surveyed parachute drop zones in land or water range areas enhance safety.

Special Warfare, NECC, or Army Personnel from HH-60H, SH-60F, or MH-60S Helicopters

There are a number of different insertion or extraction techniques that are used depending on the mission and tactical situation:

- Helicopter Rope Suspension Training (HRST) is a collective term used for various techniques used for quickly deploying troops from a helicopter in locations where the helicopter itself is unable to touch down:
- Fast Rope uses a large diameter rope attached to the helicopter at one end and loose to the ground point of insertion. A thick rope is used so that the helicopter rotor blast does not blow it around. One simply holds onto the rope with his hands and feet and slides down. Several people can slide down the same rope almost simultaneously as long as enough room is provided for each person to get out of the way when they reach the ground so that the next person will not land on them. It is quicker than rappelling because the person is not attached to the rope.
- Rappelling is similar to the fast rope technique except that it uses a smaller diameter rope and the person wears a harness that is attached to the rope by a carabineer. It is safer than fast rope, but slower.
- Special Purpose Insertion/Extraction (SPIE) was designed for use in rough terrain as well as water. This technique inserts or extracts an entire patrol at one time. Each person wears a harness and uses a carabineer to attach to "D" rings in a rope that is attached to the helicopter. The helicopter descends or lifts vertically into/from the insertion/extraction zone while ensuring that the rope and personnel are clear of obstructions. During forward flight the rope and personnel are treated as an external load and airspeeds, altitudes, and oscillations are closely monitored.
- Cast and Recovery is a method for delivering or recovering personnel to or from the water. A helicopter flies low and slow over the water near the target point and the personnel simply jump into the water one at a time. This method is also used for inserting and extracting a Combat Rubber Raiding Craft (CRRC) and its passengers.

Basic Phase (Unit Level Training) Scenario

Helicopters with the embarked personnel approach the objective area at a low altitude, between 200 ft to 400 ft, descend quickly to the insertion position, and hover about 20 ft above the ground. Once the passengers and equipment have been inserted or extracted, the helicopter departs the area.

Opposition force personnel may be employed as well as small arms with blanks or live ammunition (if permitted). Ordnance, if used, typically includes 7.62 mm, 5.56 mm and .50 cal.

These operations will vary in length depending on the transportation method and systems being used, typically from 2 to 8 hours.

Integrated and Sustainment Phase Training Scenarios

Typically do not differ from the Basic Phase Scenario, except that the procedure is done as a part of a larger operation with two or more helicopters and an assigned mission.

Special Warfare or NECC Personnel from Boats

Basic Phase (Unit Level Training) Scenario

Combat personnel use Combat Rubber Raiding Craft (CRRC), Rigid Hull Inflatable Boats (RHIB), and other boats to approach a hostile area ashore from points at sea to perform an assigned task such as obtain intelligence, destroy an assigned target, or complete another objective. The goal of this exercise is to get the personnel to or from the beach.

Opposition force personnel may be employed as well as small arms with blanks or live ammunition (if permitted). Ordnance, if used, typically includes 7.62 mm, 5.56 mm and .50 cal.

These operations will vary in length depending on the transportation method and systems being used, typically from 2 to 8 hours.

Integrated and Sustainment Phase Training Scenarios

Typically do not differ from the Basic Phase Scenario.

Special Warfare or NECC Personnel or Marines from SSN or SSGN

Several methods are used by submarines and embarked personnel to move from the submarine to the objective area:

- The Lock-in/lock-out procedure allows personnel to swim out of submerged submarines.
- The SEAL Delivery Vehicle (SDV) may be used by personnel to move from the submarine to an underwater area closer to shore.
- The Advanced SEAL Delivery System (ASDS) is a longer range submersible used to move Special Warfare personnel to the shore. It is typically carried by a specially configured SSN to a special launch point where the personnel embark and use it to move to a location where they can swim to shore.

Basic Phase (Unit Level Training) Scenario

Submarines approach a hostile area and move at a very slow speed while inserting or extracting personnel by using one, or a combination of two or more, of the three procedures discussed above. Once the personnel have inserted or extracted, the submarine will leave the area.

Opposition force personnel may be employed as well as small arms with blanks or live ammunition (if permitted) once the personnel reach the beach area. Ordnance, if used, typically includes 7.62 mm, 5.56 mm and .50 cal.

These operations will vary in length depending on the transportation method and systems being used, typically from 2 to 8 hours.

Integrated and Sustainment Phase Training Scenarios

Not typically conducted in these phases.

Local Training Considerations

Insertion/extraction operations train Special Forces (Navy, Marine Corps, and Air Force) to deliver and extract personnel and equipment in challenging environments. Apra Harbor operations in FY03 were conducted by Naval Special Warfare Unit One (NSWU-1) and EODMU-5. These operations included, but are not limited to, parachute, fastrope, rappel, Special Purpose Insertion/Extraction (SPIE), combat rubber raiding craft, and lock-in/lock-out from underwater vehicles.

Parachute Insertions and Air Assault

Special Warfare and Army personnel use fixed-winged and rotary aircraft to insert troops and equipment by parachute or helicopters that fly directly to a specified objective area, land and off load their troops or cargo.

Special Warfare, NECC, or Army Personnel Parachute from Fixed-winged Aircraft

Basic Phase (Unit Level Training) Scenario

A fixed-winged aircraft such as a C-130, or helicopter such as a MH-60, will fly to the objective area from a land based airfield. The embarked Special Warfare, NECC, or other personnel will parachute (static line or free fall) into the planned area from either a high (25,000 ft or more) or a low (1,000 ft and below) altitude; training is conducted in any altitude between the two aforementioned altitudes.

Opposition force personnel may be employed as well as small arms with blanks or live ammunition (if permitted). Ordnance, if used, typically includes 7.62 mm, 5.56 mm and .50 cal.

These operations will vary in length depending on the transportation method and systems being used, typically from 2 to 8 hours.

Integrated and Sustainment Phase Training Scenarios

Typically do not differ from the Basic Phase Scenario.

Table D-2: Parachute Insertions and Air Assault

Range Activity	Platform	System or Ordnance	No Action Alternative	Alternative 1	Alternative 2	Location
SPECIAL WARFARE						
PARACHUTE INSERTION	SEAL Platoon/Squad; EOD Platoon/Squad; ARMY Platoon/Squad USAF Platoon/Squad; C-130; CH-46; H-60	Square Rig or Static Line	6 Events; 2 to 8 hours	12 Events; 2 to 8 hours	12 Events; 2 to 8 hours	PRI: Orote Pt. Airfield; Northwest Airfield; Orote Pt. Triple Spot SEC: Finegayan DZ; Apra Harbor; Navy Munitions Site Breacher House

Training Considerations

Surveyed parachute drop zones in land or water range areas enhance safety.

<u>Special Warfare, NECC, or Army Personnel from HH-60H, SH-60F, or MH-60S Helicopters</u>

Basic Phase (Unit Level Training) Scenario

Helicopters with the embarked personnel approach the objective area at a low altitude, between 200 ft to 400 ft, descend quickly to the insertion position, land and disembark or embark personnel and/or equipment. Once the passengers and equipment have been inserted/extracted, the helicopter departs the area.

Opposition force personnel may be employed as well as small arms with blanks or live ammunition (if permitted). Ordnance, if used, typically includes 7.62 mm, 5.56 mm and .50 cal.

These operations will vary in length depending on the transportation method and systems being used, typically from 2 to 8 hours.

Local Training Considerations

OPA supports personnel, equipment, and CDS airborne parachute insertions.

Floating Mine Neutralization - Explosive Ordnance Disposal (EOD)

Explosive Ordnance Disposal personnel use special equipment to evaluate threat mines, then explosive charges to destroy the mine in order to create a safe channel for friendly shipping.

Table D-3: Floating Mine Neutralization – Explosive Ordnance Disposal

Range Activity	Platform	System or Ordnance	No Action Alternative	Alternative 1	Alternative 2	Location
MINE WARFARE (MIW)						
FLOATING MINE NEUTRALIZATION	RHIB; CRRC; Small Craft	Floating mine shape; 5 – 20 lb NEW	8 Events; (2 – 8 hours each)	20 Events; (2 – 8 hours each)	20 Events; (2 – 8 hours each)	PRI: Agat Bay SEC: Piti

EOD Personnel with Mine Neutralization Charges

Basic Phase (Unit Level Training) Scenario

EOD personnel detect, identify, evaluate, and neutralize mines. The EOD mission is typically to locate and neutralize mines after they have been initially located by another source, such as a MCM class ship or a MH-53 or MH-60S helicopter. Once the mine shapes are located, EOD divers are deployed from a ship via Combat Rubber Raiding Craft (CRRC) to further evaluate and “neutralize” the mine in the water. This is normally done with an explosive device and may involve the detonation of one or two explosive charges of up to 20 pounds of TNT equivalent.

Mine training shapes or other exercise support equipment and a range area that will support the use of live ordnance is required for a six to eight hour window. These operations are normally conducted during daylight hours for safety reasons. Mine Neutralization training in Inner Apra Harbor (IAH) typically consists of locating and neutralizing LIMPET mines (inert shapes for training). LIMPET mine training shapes are attached to a ship or object that is to be destroyed by the mine.

Local Training Considerations

This EOD event in the Agat Bay or Piti Floating Mine Neutralization Area is the location and neutralization of a floating or near surface mine by EOD divers. The neutralization of the mine (the portion of the exercise that involves the use of ordnance) is typically scheduled during daylight hours for safety reasons and completed within a two hour period. Divers deploy from RHIB, CRRC, or small craft, and a diver will place the explosive next to or on each inert mine shape. The EOD divers control the initiation of each charge. Once the neutralization charge is placed on or near the mine, the divers will return to their craft and proceed to a safe location for detonation. Based on charge size and operating conditions, EOD will determine a “safe time” and distance needed from the mine before they detonate the charge. Typically two shots per training event are conducted, with a second charge detonated 1-2 hours after the first shot. After the detonation portion of the exercise is completed, the mine shape is recovered. Divers are redeployed to the detonation area to verify that the mine shape was destroyed or to aid in recovery of the mine shape.

Underwater Demolitions

Navy SEALS or EOD personnel use explosive charges to destroy obstacles or other structures in an underwater area that could cause interference with friendly or neutral forces and planned operations.

Table D-4: Underwater Demolitions

Range Activity	Platform	System or Ordnance	No Action Alternative	Alternative 1	Alternative 2	Location
MINE WARFARE (MIW)						
UNDERWATER DEMOLITION	RHIB; CRRC; Small Craft	Bottom/mid-moored mine shape 5 – 20 lb NEW	22 Events; (2 – 8 hours each)	30 Events; (2 – 8 hours each)	30 Events; (2 – 8 hours each)	PRI: Agat Bay SEC: Apra Harbor (10lb NEW max)

<u>NSW or EOD Personnel with Explosive Charges</u>

Basic Phase (Unit Level Training) Scenario

NSW or EOD personnel locate mines, barriers or obstacles designed to deny access to an area, and then use explosive charges to destroy them.

Training Considerations

This training provides NSW and EOD personnel with experience in placing and detonating explosives to achieve best results.

Local Training Considerations

Underwater demolitions are designed to train personnel in the destruction of mines, obstacles or other structures in an area to prevent interference with friendly or neutral forces and non-combatants. It provides Navy Special Warfare and EOD teams experience detonating underwater explosives. Apra Harbor supports this training near the Glass Breakwater and Buoy 702, at a depth of 125 feet and using up to a 10 pound (NEW) charge. The Agat Bay Underwater Detonation Area supports this training using up to 20 pound (NEW) charge. Lying outside of Apra Harbor and to the north of Glass Breakwater is the Piti Floating Mine Neutralization area. Piti recorded zero usage in FY03.

Breaching

Special Warfare, Army, and USMC personnel use explosives to gain access to buildings where enemy personnel or material could be located or to investigate the building itself.

Breaching with Explosive Charges

Breaching operations train personnel to employ any means available to break through or secure a passage through an enemy defense, obstacle, minefield, or fortification. This process enables a unit to maintain its mobility by removing or reducing natural and man-made obstacles. Breaching training is designed to provide experience in knocking down doors to enter a building or structure or destroying obstacles that could block access to vehicles or personnel.

Basic Phase (Unit Level Training) Scenario

Six to 12 personnel use small unit tactics to approach a fortified building that may contain enemy personnel or material, and force is required to gain access. Explosive charges are set around door frames or other specified areas where the explosion will breach the door, wall, or other area and allow access into the building. In simple settings, a door and door frame is erected in a breaching building or demolition pit or in a MOUT where personnel practice knocking down the door using explosives that are normally no more than 1.2 pound Net Explosive Weight (NEW).

Local Training Considerations

Breaching operations train personnel to employ any means available to break through or secure a passage through an enemy defense, obstacle, minefield, or fortification. This enables a force to maintain its mobility by removing or reducing natural and man-made obstacles. In the Urban Warfare sense, breaching operations are designed to provide teams experience knocking down doors to enter a building or structure. During the conduct of a normal breach operation personnel practice knocking down the door using explosives that are no more than 3 pounds NEW and normally 1.2 pounds NEW or less. The Navy Munitions Site Breaching House is the only facility in MIRC that permits explosive breaching. Explosives at Orote Point Close Quarters Combat (OPCQC) are not permitted, which limits the value of conducting breaching training at OPCQC.

Table D-5: Breaching

Range Activity	Platform	System or Ordnance	No Action Alternative	Alternative 1	Alternative 2	Location
SPECIAL WARFARE						
BREACHING (Buildings, Doors)	SEAL Platoon/Squad; EOD Platoon/Squad; ARMY Platoon/Squad; USMC Platoon/ Squad;	Breach House (1 lbs NEW C4 max/door)	10 Events; 2-8 hours (15 lbs NEW C4)	20 Events; 2-8 hours (30 lbs NEW C4)	20 Events; 2-8 hours (30 lbs NEW C4)	Navy Munitions Site Breacher House

Land Demolitions

EOD personnel use explosive charges to destroy land mines, explosive devices, such as improvised explosive devices, bombs, structures, or other items as required.

Table D-6: Land Demolitions

Range Activity	Platform	System or Ordnance	No Action Alternative	Alternative 1	Alternative 2	Location
SPECIAL/EXPEDITIONARY WARFARE						
LAND DEMOLITIONS (IED DISCOVERY/ DISPOSAL)	NECC EOD Platoon/ Squad; USMC EOD Platoon/ Squad; USAF EOD Platoon/ Squad: HMWWV; TRUCK	IED Shapes	60 Events; 2 – 8 hours	120 Events; 2 – 8 hours	120 Events; 2 – 8 hours	PRI: Guam, Orote Pt. Airfield; Orote Pt. CQC; Polaris Pt. Field; Andersen South; Northwest Field SEC: Northern/Southern Land Navigation Area; Munitions Site Breacher House; Tinian MLA

<u>EOD Personnel with Explosive Charges</u>

Basic Phase (Unit Level Training) Scenario

EOD detachments transit to the training site in trucks or other light wheeled vehicles, sometimes conducting convoy operations or employing other unit tactics enroute to the site. A search of a suspect area is conducted to locate inert land mines buried in the sand or to locate a designated target for destruction. Buried land mines and unexploded ordnance require the detachment to employ probing techniques and metal detectors for locating the mine or object and the use of hand tools and digging equipment to excavate them. Once they are exposed and/or properly identified, the detachment neutralizes the threats by using small amounts of simulated or live explosives (EOD land demolitions training using live explosives in the MIRC are authorized in an EOD pit only).

Integrated and Sustainment Phase Training Scenarios

Not typically conducted in these phases.

Training Considerations

Land demolitions are designed to train forces to explode and destroy enemy personnel, vehicles, aircraft, obstacles, facilities, or terrain on land. These operations are also designed to develop and hone EOD detachment mission proficiency in the location, excavation, identification and neutralization of buried land mines or other hazardous objects.

Local Training Considerations

Land demolitions training is designed to develop and hone EOD detachment mission proficiency in location, excavation, identification, and neutralization of buried land mines. During the training, teams transit to the training site in trucks or other light wheeled vehicles. A search is conducted to locate inert (non-explosively filled) land mines or Improvised Explosive Devices (IEDs) and then designate the target for destruction. Buried land mines and UXO require the detachment to employ probing techniques and metal detectors for location phase. Use of hand tools and digging equipment is required to excavate. Once exposed and/or properly identified, the detachment neutralizes threats on site using simulated explosives only.

Visit, Board, Search, and Seizure (VBSS)

Helicopters and surface ships deliver boarding parties to suspect surface vessels to inspect and examine the vessel's papers or examine it for compliance with applicable resolutions or sanctions. Seizure of the vessel (that is confiscating or taking legal possession of the vessel and contraband (goods or people)) could result if the vessel is found in violation of any applicable resolutions or sanctions.

Table D-7: Visit, Board, Search, and Seizure

Range Activity	Platform	System or Ordnance	No Action Alternative	Alternative 1	Alternative 2	Location
SURFACE WARFARE						
Visit, Board, Search and Seizure/Maritime Interception Operation (VBSS/MIO)	RHIB, Small Craft, Ship, H-60	n/a	3 Events; 2-3 hours	6 Events; 2-3 hours	8 Events; 2-3 hours	PRI: Apra Harbor SEC: MI Maritime

CG, DDG, FFG, LPD, LSD with Shipboard or Special Forces Boarding Teams with Small Arms

Basic Phase (Unit Level Training) Scenario

Ships will typically be on patrol in a designated ocean or restricted area to watch for vessels that may need to be inspected or seized. When a suspect vessel is sighted, the ship will approach the suspect vessel at a speed of 20 kts or more while preparing to launch its organic helicopter or small boat and using its radio to talk to the suspect vessel to get it to assume an assigned course and slow speed. A cooperative boarding will allow the armed boarding party to board and conduct the inspection.

An uncooperative boarding is the more typical training scenario and may actually require a clandestine approach to the suspect vessel and use of force. An organic helo and small boat will still be used to board the suspect vessel, but shipboard or Special Forces boarding teams with armed force may be required to make the boarding. Small arms with inert blanks may be used. The entire exercise may last two to three hours.

Training Considerations

A range support vessel or other commercial style vessel can be used as the suspect vessel to be boarded and may be staffed with opposing forces to create a better training environment.

SH-60B/F, HH-60H, MH-60R/S with Machine Guns and Shipboard or Special Forces Boarding Teams with Small Arms

Basic Phase (Unit Level Training) Scenario

Helicopters supply the transportation for the boarding party from a surface ship to the suspect vessel to be boarded, as described above, and provide added fire power from onboard 7.62 mm or .50 Cal machine guns (see GUNEX (A-S)) if required in an uncooperative mission. The helicopter will approach the suspect vessel, use an appropriate insertion/extraction method (see Insertion/Extraction - HELO) for the tactical situation to place the boarding party on the suspect vessel, and then standby in a hover or close proximity flight pattern to provide armed support as required.

Training Considerations

A range support vessel or other commercial style vessel can be used as the suspect vessel to be boarded and may be staffed with opposing forces to create a better training environment.

Amphibious Raid

Marine amphibious forces make swift incursions into or temporarily occupy a hostile territory or area for a specified purpose and a specified time, then make a planned withdrawal. Raids are often conducted against objectives requiring specific results that may not be achieved by any other means. Because of these mission requirements, the Marine Expeditionary Unit (Special Operations Capable) (MEU (SOC)) is a unit that has been specially structured to achieve specific mission requirements in unique situational settings against expected threat force structures.

A Marine amphibious raid force will consist of varying numbers of aviation, infantry, engineering, and fire support forces necessary for the specific mission to be accomplished. Because they typically lack the ability to overwhelm a forewarned and well-armed defender, the riskiest phases of an Amphibious Raid are the insertion and extraction phases. These phases depend on the availability of sufficient and dependable intelligence to allow the raid force to approach the target without in route engagement, complete the mission expeditiously, and withdraw before the enemy can respond.

Table D-8: Amphibious Raid

Range Activity	Platform	System or Ordnance	No Action Alternative	Alternative 1	Alternative 2	Location
AMPHIBIOUS WARFARE (AMW)						
Amphibious Raid Special Purpose MAGTF	1 LHA or LHD, 1 LPD, and 1 LSD. Tailored MAGTF.	4-14 AAV/EFV or LAV/LAR; 0-5 LCAC; 0-2 LCU; 4 H-53; 12 H-46 or 10 MV-22; 2 UH-1; 4 AH-1; 4 AV-8	0	2 events (raid, offload, backload)	2 events (raid, offload, backload)	PRI: Apra Harbor; Reserve Craft Beach; Polaris Point Beach (MWR) and Polaris Point Field; Orote Point Airfield; Field; Sumay Cove and MWR Marina Ramp SEC: Tinian Military Leased Area; Unai Chulu (beach) and Tinian Harbor; North Field.

<u>MEU (SOC) with Small Boats or Mechanized Assault Craft and Blank Small Arms Ammunition</u>

Basic Phase (Unit Level Training) Scenario

Typical Amphibious Raid missions might be mounted to:

- Inflict loss or damage a specified target
- Seize a port or airfield for use by "friendly" forces
- Secure intelligence information
- Evacuate combatant or non-combatant personnel
- Create a tactical diversion.

A typical Amphibious Raid force may be comprised of a reinforced company (100-150 personnel) landed by small boat or mechanized assault craft on a beachhead, or inserted by assault support aircraft into a landing zone (LZ). The company would then proceed to a designated objective area within the range complex to carry out the assigned mission. When the mission is successfully accomplished, the company would then proceed to an extraction point for return to ships in the ESG.

Because it is the foundation for MEU operations, the amphibious raid is conducted more prevalently within the Pre-deployment Training Plan. A single MEU is expected to execute 16-20 training raids for its 3 companies and attachments in the basic phase scenario

Integrated and Sustainment Phase Training Scenarios

Unlike an Amphibious Assault that is intended to establish a more permanent presence in a hostile territory, the Amphibious Raid makes a swift incursion into, or a temporary occupation of, an objective, followed by a planned withdrawal.

The procedures used during these phases are built on those developed during the Basic Phase, but the forces will accomplish their mission under the larger umbrella of the ESG and with the additional support forces available from the ESG.

Local Training Considerations

Reserve Craft Beach (RCB) is capable of supporting a small Expeditionary Raid training event followed by a brief administrative buildup of forces ashore. In FY03 up to 300 31st MEU personnel and equipment were moved ashore at RCB via LCAC.

Military Operations in Urban Terrain (MOUT)

USMC, Army, Air Force, Special Warfare, and NECC personnel use combat tactics appropriate for a small city environment inhabited by noncombatants but occupied by a hostile force to search out and capture or destroy the hostile force.

Table D-9: Military Operations in Urban Terrain

Range Activity	Platform	System or Ordnance	No Action Alternative	Alternative 1	Alternative 2	Location
EXPEDITIONARY WARFARE						
MILITARY OPERATIONS IN THEATER (MOUT) TRAINING	USMC Infantry Company: AH-1, UH-1; H-46 or MV-22; H-53; AAV, LAV, HMMWV, TRUCK	5.56 mm blanks/Simunitions	2 events, 7-21 days/event	5 events of 7-21 days/event	5 events of 7-21 days/event	PRI: Guam; AAFB South; Finegayan Communication Annex; Barrigada Housing; Northwest Field SEC: Tinian; Rota; Saipan
	USAF RED HORSE SQUADRON: TRUCK, HMMWV; MH-53; H-60		2 events, 3-5 days/event	4 events, 3-5 days/event	4 events, 3-5 days/event	
	Navy NECC Company: HMWWV, TRUCK		2 events, 3-5 days/event	4 events, 3-5 days/event	4 events, 3-5 days/event	
	Army Reserve/GUARNG Company; HMWWV, TRUCK		2 events, 3-5 days/event	4 events, 3-5 days/event	4 events, 3-5 days/event	
SPECIAL WARFARE						
MILITARY OPERATIONS IN THEATER (MOUT) TRAINING	SEAL Platoon/Squad; EOD Platoon/Squad; HMWWV; TRUCK	5.56 mm blanks/Simunitions	6 events of 3-5 days/event	8 events of 3-5 days/event	10 events of 3-5 days/event	PRI: Guam; AAFB South; Finegayan Communication Annex; Barrigada Housing; Navy Munitions Site Breaching House SEC: Tinian; Rota; Saipan

MOUT Personnel with Small Arms Weapons

Basic Phase (Unit Level Training) Scenario

Patrols use advanced, offensive, close-quarters battle techniques to move through a hostile urban environment where noncombatants are or may be present and collateral damage must be kept to a minimum. Techniques used include: advanced breaching to enter buildings or clear rooms; clearing stairwell; selective target engagement to ensure noncombatants are not harmed; and dynamic assault techniques, to ensure collateral damage is kept to a minimum.

Organizational equipment used during these operations includes 7.62 mm, 5.56 mm, 12-gauge, and 9 mm small arms, 40 mm grenades, and breaching explosive charges. Blanks from organizational equipment or "paint ball" type weapons are typically employed over different portions of the training scenario, which is usually especially tailored for a possible real world scenario.

Integrated and Sustainment Phase Training Scenarios

Typically differ from the Basic Phase Scenario by the number of personnel that will be involved and the more command and control that will be used. The operation may also be supported by helicopters for insertion and extraction or close air support, and by UAVs for intelligence information.

MOUT forces in these phases are more typically geared for Marine Corps missions at company-level size operations (100-150 personnel) to battalion-level size operations (1,000 personnel).

Training Considerations

A "city" with opposing forces is required to get the most out of MOUT training and gain the experience required by the complicating factors of urban warfare which include:

- Distinguishing civilians from hostiles
- Three dimensional environment
- Limiting fields of view and fire caused by buildings
- Enhanced concealment and cover for hostiles
- Below ground infrastructure
- Booby traps
- Snipers.

MOUT training can consist of more than one type of scenario. One might be a "raid," in which small teams use MOUT tactics to seize and secure an objective, accomplish their mission and withdraw. Another might be a Marine Expeditionary Force (MEF) using MOUT tactics to seize and secure an objective for the long term. In either case, training to neutralize enemy forces must be accomplished in a built-up area featuring structures, streets, vehicles and civilian population. It is manpower intensive, requiring close fire and maneuver coordination and extensive training.

Local Training Considerations

OPCQC supports "raid" type MOUT training on a limited basis.

USMC makes extensive use of Andersen South during Training in Urban Environment Exercise (TRUEX) events.

Airfield Seizure

Special Warfare, Army and Marine Corps units use combat tactics appropriate for seizing and securing an occupied enemy airfield in order to make it available for follow-on friendly force use. Air Force and NECC units specialize in securing and repairs of a seized airfield.

Table D-10: Airfield Seizure

Range Activity	Platform	System or Ordnance	No Action Alternative	Alternative 1	Alternative 2	Location
SPECIAL/EXPEDITIONARY WARFARE						
SEIZE AIRFIELD	SEAL Company/ Platoon USMC Company/ Platoon ARMY Company/ Platoon USAF Squadron C-130; MH-53; H-60; HMWWV; TRUCK	5.56 mm blank/Simulations	2 Events; 1 – 3 days	12 Events; 1 – 3 days	12 Events; 1 – 3 days	PRI: Northwest Field SEC: Orote Pt. Airfield; Tinian North Field

Personnel with Small Arms Weapons

Basic Phase (Unit Level Training) Scenario

NSW, NECC, or Marine Corps patrols use advanced, offensive, raid and close-quarters battle techniques to move through a hostile environment where noncombatants are or may be present and collateral damage must be kept to a minimum in order to be able to use the airfield facilities after they have been seized.

The raid/seizure force typically advances from over the horizon, assaulting across a hostile territory in a combination of helicopters, VTOL aircraft, and other landing craft.

Organizational equipment used during this operation includes 7.62 mm, 5.56 mm, 12-gauge, and 9 mm small arms, 40 mm grenades, and breaching explosive charges. Blanks from organizational equipment or "paint ball" type weapons are typically employed over different portions of the training scenario, which is usually especially tailored for a possible real world scenario.

Local Training Considerations

Northwest Field (NWF) is a primary site for this training. The USAF Red Horse Squadron will frequently conduct this type of training.

Direct Action

Special Forces or NECC personnel use covert or overt small unit tactics against an enemy force to seize, damage, or destroy a target and/or capture or recover personnel or material.

Table D-11: Direct Action

Range Activity	Platform	System or Ordnance	No Action Alternative	Alternative 1	Alternative 2	Location
SPECIAL WARFARE						
DIRECT ACTION	SEAL Tactical Air Control Party (TAC-P); RHIB; Small Craft.	M-16, M-4, M-249 SAW, M-240G, .50 cal, M-203 (5.56 /7.62 mm/ .50 cal round/ 40mm HE)	2 Events; 1 day (2,000 rounds)	3 Events; 1 day (3,000 rounds)	3; events 1 day (3,000 rounds)	FDM (R-7201)
	SEAL Platoon/Squad; NECC Platoon/Squad; USMC Platoon/Squad; ARMY Platoon/Squad; USAF Platoon/Squad	5.56 mm blanks/Simunitions 9mm (Orote Pt. Combat Qualification Center - OPCQC) 1.5 lb NEW C4 (Navy Munitions Site Breaching House)	32 Events; 2 - 8 hours (12,500 9mm) (10.5 lb NEW C4)	40 Events; 2 - 8 hours (15,000 9mm) (15 lb NEW C4)	48 Events; 2 - 8 hours (17,500 9mm) (19.5 lb NEW C4)	PRI: OPCQC and Navy Munitions Site Breacher House SEC: Tarague Beach CQC and Navy Munitions Site Breacher House.

<u>Personnel with Small Arms Weapons and Explosive Devices</u>

Basic Phase (Unit Level Training) Scenario

A squad or platoon size force are inserted into and later extracted from a hostile area by helicopter, Combat Rubber Raiding Craft (CRRC), or other technique, and then use small-scale offensive actions to attack hostile forces or targets. These offensive actions can include: raids, ambushes, standoff attacks by firing from ground, air, or maritime platforms, designating or illuminating targets for precision-guided munitions, providing support for cover and deception operations, and sabotage.

Opposing forces and targets within range areas are required for realism. Small arms such as 7.62 mm, 5.56 mm, 9 mm, 12-gauge, 40 mm grenades, laser illuminators, and other squad or platoon weapons may be used against live fire targets, or with blanks.

Training Considerations

This exercise may be combined with other exercises such as insertion and extraction, close air support, and others.

Local Training Considerations

NSWU-1 is capable of using small craft to island hop from Guam to Rota, Rota to Tinian, Tinian to Saipan, and Saipan to FDM. This is not a frequent event. Once at FDM, they will employ small arms, grenades, and crew served weapons in direct action against targets on the island. They may also participate in TACP/FAC training in conjunction with a Bombing Exercise (Air-to-Ground) (BOMBEX (A-G)).

NSWU-1 and visiting Special Forces training in the MIRC will frequently include training that utilizes the access provided by Gab Gab Beach to Apra Harbor and Orote Point training areas.

Maneuver

Marine Corps units practice the maneuver and employment of forces in a non live fire environment such that the forces may achieve a position of advantage over an enemy force and accomplish operational or strategic objectives.

Table D-12: Maneuver

Range Activity	Platform	System or Ordnance	No Action Alternative	Alternative 1	Alternative 2	Location
SPECIAL/EXPEDITIONARY WARFARE						
MANEUVER (Convoy; Land Navigation)	USMC Company/Platoon Army Company/Platoon	Trucks; HMWWV;AAV/LAV	8 Events; 8 -24 hours	16 Events; 8 – 24 hours	16 Events; 8 – 24 hours	PRI: Northwest Field; AAFB South; Northern and Southern Land Navigation Area; Tinian MLA SEC: Finegayan Annex; Barrigada Annex; Orote Pt. Airfield;

<u>Marine Corps and Army Personnel</u>

Basic Phase (Unit Level Training) Scenario

This training may be conducted at the squad level or at the Battalion, Regiment, Division, Force, or Joint level.

Local Training Considerations

Northern Land Navigation Area and Southern Land Navigation Area support teams on foot only, no convoy training. Limited convoy training is possible at Andersen South, and Finegayan and Barrigada Annexes.

Gunnery Exercise (Surface-to-Surface) (Boat): GUNEX (S-S)(Boat)

A small boat uses a machine gun and small arms to attack and disable or destroy a surface target that simulates another ship, boat, swimmer, floating mine or near shore land targets.

A number of different types of boats are used depending on the unit using the boat and their mission. Boats are most used by NSW teams and Navy Expeditionary Combat Command (NECC) units (Naval Coastal Warfare, Inshore Boat Units, Mobile Security Detachments, and Explosive Ordnance Disposal). These units are used to protect ships in harbors and high value units, such as: aircraft carriers, nuclear submarines, liquid natural gas tankers, etc., while entering and leaving ports, as well as to conduct insertion and extractions, and various naval special warfare operations.

The boats used by these units include: Small Unit River Craft (SURC), Combat Rubber Raiding Craft (CRRC), Rigid Hull Inflatable Boats (RHIB), Patrol Craft, and many other versions of these types of boats. These boats use inboard or outboard, diesel or gasoline engines with either propeller or water jet propulsion.

Table D-13: Gunnery Exercise (Surface-to-Surface) (Boat): GUNEX (S-S) (Boat)

Range Activity	Platform	System or Ordnance	No Action Alternative	Alternative 1	Alternative 2	Location
SURFACE WARFARE (SUW)						
GUNEX Surface-to-Surface (Small arms)	Ship, RHIB, small craft. Barrel or Inflatable tgt.	M-16, M-4, M-249 SAW, M-240G, .50 cal, M-203 (5.56 /7.62 mm/ .50 cal round/ 40mm TP)	24 (12,000 rounds)	32 (16,000 rounds)	40 (20,000 rounds)	PRI: MI Maritime, >3 nm from land SEC: W-517

<u>**Navy and Coast Guard Boats with .50 cal, 7.62 mm or 40 mm Machine Guns**</u>

This exercise is usually a live fire exercise, but at times blanks may be used so that the boat crews can practice their boat handling skills for the employment of the weapons while minimizing risk to personnel and equipment associated with firing live weapons.

Basic Phase (Unit Level Training) Scenario

Boat crews may use high or low speeds to approach and engage targets simulating other boats, swimmers, floating mines, or near shore land targets with .50 cal, 7.62 mm, or 40 mm weapons.

Integrated and Sustainment Phase Training Scenarios

Typically do not differ from the Basic Phase Scenario, except for the additional command and control coordination involved.

Training Considerations

The purpose of this exercise is to develop marksmanship skills and small boat handling tactics and skills required to employ these weapons. It usually lasts one to two hours.

Local Training Considerations

Surface gunnery exercises take place in the open ocean to provide gunnery practice for Navy and Coast Guard ship and small craft crews supporting NSWU-1, EODMU-5, and Mobile Security Squadron Seven (MSS-7). Local GUNEX training activity conducted typically involve only non-maneuvering targets such as a MK-42 Floating At Sea Target (FAST) or a MK-58 marker (smoke) buoy, or a steel drum. The systems employed against surface targets include the 5-inch, 76mm, 25mm chain gun, 20mm Close In Weapon System (CIWS), .50 caliber machine gun, 7.62mm machine gun, small arms, and 40mm grenade.

Gunnery Exercise (Surface-to-Surface) (Ship) (GUNEX [S-S] [Ship])

Ship gun crews engage surface targets at sea with their main battery 5-inch and 76 mm guns as well as smaller surface targets with 25 mm, .50 cal, or 7.62 mm machine guns with the goal of disabling or destroying the threat ship.

Table D-14: Gunnery Exercise (Surface-to-Surface)(Ship) (GUNEX [S-S] [Ship])

Range Activity	Platform	System or Ordnance	No Action Alternative	Alternative 1	Alternative 2	Location
SURFACE WARFARE (SUW)						
GUNEX Surface-to-Surface (Ship)	LHA, LHD, LSD, and LPD. Barrel, Inflatable tgt.	.50 cal MG	1 (2,400 rounds)	5 (12,000 rounds)	5 (12,000 rounds)	PRI: W-517 SEC: MI Maritime, >12 nm from land
		.25 mm MG	1 (1,600 rounds)	5 (8,000 rounds)	5 (8,000 rounds)	
	CG and DDG. Barrel or Inflatable tgt. or towed sled.	5" gun	4 (160 rounds)	8 (320 rounds)	10 (400 rounds)	
	FFG. Barrel or Inflatable tgt. or towed sled.	76 mm	2 (60 rounds)	4 (120 rounds)	5 (150 rounds)	

CG and DDG with 5-inch and FFG with 76 mm Guns

There are three types of main battery shipboard guns currently in use: 5-inch/54 (CG and DDG), 5-inch/62 (DDG-81 and newer), and 76 mm (FFGs). Both 5-inch guns use the same types of 5-inch projectiles for training exercises. The difference between the 5-inch guns is the longer range of the 5-inch/62 because of the larger powder propulsion charge.

Basic Phase (Unit Level Training) Scenario

A slow (5 kts) or high (30 kts) speed simulated enemy ship or boat approaches the CG/DDG/FFG from about 10 nm, is detected by the ship's radar and determined to be hostile. The target is tracked by radar, and when it is within five to nine nm, it is engaged by approximately 60 rounds of 5-inch or 76 mm, fired with an offset so as not to actually hit the targets over duration of about 3 hours. Live or inert training rounds may be used. After impacting the water, the live rounds are expected to detonate within 3 ft of the surface. Inert rounds and fragments from the live rounds will sink to the bottom of the ocean.

The main battery guns have a requirement to attack high-speed, maneuvering, towed or remotely controlled surface targets such as the QST-35 Seaborne Powered Target (SEPTAR), High Speed Maneuverable Surface Target (HSMST), or a remote controlled Jet Ski. These types of targets have not been available in the MIRC.

Integrated and Sustainment Phase Training Scenarios

These two scenarios will be similar to each other and the Basic Phase Scenario, but will have more "friendly" ships (3 to 5) participating. Additional ships will increase the number of rounds fired proportionally.

<u>LHA, LHD, LPD, and LSD with 25 mm, .50 cal or 7.62 mm Machine Guns and CG, DDG, FFG, and CVN with .50 cal or 7.62 mm Machine Guns</u>

While main battery guns are designed for both offensive and defensive use against larger, ship-sized targets, these smaller caliber machine guns are designed to provide close range defense against patrol boats, smaller boats, swimmers, and floating mines.

Amphibious ships, such as LHA, LHD, LPD, and LSD use 25 mm machine guns as their principal gun to provide a defensive gunfire capability for the engagement of a variety of smaller surface targets. Most all of these amphibious ships, as well as the CG, DDG, FFG, and CVN are also equipped with .50 cal or 7.62 mm machine guns.

Basic Phase (Unit Level Training) Scenario

Ships use machine guns to practice defensive marksmanship, typically against non-maneuvering floating targets. Targets are engaged with after closing the target to within about 2,000 yards for 25 mm, 900 yards for .50 cal, and 400 yards for 7.62 mm; between 200 and 800 rounds are typically expended.

The target is typically a Floating At-Sea Target (FAST), a MK-58 smoke, or a steel drum. Targets are expended during the exercise and are not recovered.

Integrated and Sustainment Phase Training Scenarios

Typically do not differ from the Basic Phase Scenario.

Bombing Exercise (Air-to-Surface) (BOMBEX [A-S])

Strike fighter and maritime patrol aircraft deliver bombs against surface maritime targets, day or night, with the goal of destroying or disabling enemy ships or boats.

Table D-15: Bombing Exercise (Air-to-Surface) (BOMBEX [A-S])

Range Activity	Platform	System or Ordnance	No Action Alternative	Alternative 1	Alternative 2	Location
SURFACE WARFARE (SUW)						
BOMBEX (Air to Surface)	FA-18; AV-8B; MPA (MK 58 Smoke tgt. or towed sled)	MK 82 I; BDU-45; MK 76 (Inert Rounds)	16 Events; 1 – 2 hours (48 rounds)	24 Events; 1 – 2 hours (72 rounds)	30 Events; 1 – 2 hours (90 rounds)	PRI: W-517 SEC: MI Maritime, >12 nm from land; ATCAAs

F/A-18C/E/F with Unguided or Precision-guided Munitions

Unguided munitions: MK-76 and BDU-45 (inert training bombs); MK-80 series (inert or live); MK-20 Cluster Bomb (inert or live).

Precision-guided munitions: Laser-guided bombs (LGB) (inert or live); Laser-guided Training Rounds (LGTR) (inert); Joint Direct Attack Munition (JDAM) (inert or live).

Basic Phase (Unit Level Training) Scenario

A flight of two aircraft will approach the target from an altitude of between 15,000 ft to less than 3,000 ft and, when on an established range, will adhere to designated ingress and egress routes. Typical bomb release altitude is below 3,000 ft and within a range of 1000 yards for unguided munitions, and above 15,000 ft and in excess of 10 nm for precision-guided munitions. Laser designators from either own aircraft, a support aircraft, or ground support personnel are used to illuminate certified targets for use with lasers when using laser guided weapons.

Integrated and Sustainment Phase Training Scenarios

Typically involves an at-sea simulated strike scenario with a flight of four or more aircraft, with or without a designated opposition force (OPFOR).

Training Considerations

Strike fighter pilots can fulfill this training requirement against either a land or water target. It rarely involves dropping live ordnance in the open ocean.

Unguided munitions: Usually conducted at land ranges with inert or live ordnance, or water ranges with grounded ship hulks available for targets. MK-76 and BDU-48 inert bombs are the most common weapon allocation.

Precision-guided munitions: The very large safety footprints of these bombs limit their employment to impact areas on large land ranges, such as the Fallon Training Range Complex, or at-sea during a Sinking Exercise (SINKEX). Each squadron's training allowance is very small (only one or two per year), severely limiting the total fleet-wide annual expenditure of these weapons.

P-3C and P-8A Maritime Patrol Aircraft (MPA) with Unguided Munitions

Unguided munitions: BDU-45 inert bomb; MK-82 (500 Lb bomb) (inert or live); MK-20 (Rockeye cluster bomb) (inert or live); CBU-99 (cluster bomb) (inert or live).

Basic Phase (Unit Level Training) Scenario

MPA use bombs to attack surfaced submarines and surface craft that would not present a major threat to the MPA itself. The MPA is larger and slower than an F/A-18, so its bombing tactics differ markedly. A single MPA approaches the target at a low altitude. In most training exercises, it drops inert training munitions, such as the BDU-45 on a MK-58 smoke float used as the target.

Integrated and Sustainment Phase Training Scenarios

Typically do not differ from the Basic Phase Scenario, except that a more realistic target may be available and live ordnance may be expended, such as during a SINKEX.

Training Considerations

MPA pilots can fulfill this training requirement against either a land or water target, but it is usually conducted within the Warning Area above a water range with inert ordnance against a MK-58 smoke as the target.

The annual ordnance expenditure allocation typically authorizes only a very limited number of live munitions. This Commander Naval Air Force allocation should be reviewed if a specific number of live weapons are needed for a specific requirement.

Gunnery Exercise (Air-to-Surface) (GUNEX [A-S])

Strike fighter aircraft and helicopter crews, including embarked Naval Special Warfare personnel use guns to attack surface maritime targets, day or night, with the goal of destroying or disabling enemy ships, boats, or floating or near-surface mines. Typical event lasts 1 to 2 hours.

Table D-16: Gunnery Exercise (Air-to-Surface) (GUNEX [A-S])

Range Activity	Platform	System or Ordnance	No Action Alternative	Alternative 1	Alternative 2	Location
SURFACE WARFARE						
GUNEX Air-to-Surface	SH-60; HH-60; MH-60R/S; UH-1; CH-53; FA-18; AH-1W; F-15; F16; F-22; AV-8B; A-10 (Barrel or MK-58 smoke tgt.)	7.62 mm MG	150 (30,000 rounds)	200 (40,000 rounds)	200 (40,000 rounds)	PRI: W-517 SEC: MI Maritime, >12 nm from land; ATCAAs
		.50 cal MG	10 (2,000 rounds)	20 (4,000 rounds)	20 (4,000 rounds)	
		20 mm cannon	50 (5,000 rounds)	100 (10,000 rounds)	100 (10,000 rounds)	
		25 mm cannon	10 (1,000 rounds)	40 (4,000 rounds)	40 (4,000 rounds)	
		30 mm cannon	0	15 (1,500 rounds)	15 (1,500 rounds)	

F/A-18C/E/F with Vulcan M61A1/A2 20 mm Cannon

Basic Phase (Unit Level Training) Scenario

A flight of two aircraft will begin its descent to the target from an altitude of about 3,000 ft while still several miles away. Within a distance of 4,000 ft from the target, each aircraft will fire a burst of about 30 rounds before reaching an altitude of 1,000 ft, then break off and reposition for another strafing run until each aircraft expends its exercise ordnance allowance of about 250 rounds.

Integrated and Sustainment Phase Training Scenarios

Typically do not differ from the Basic Phase Scenario.

Training Considerations

Strike fighter pilots can fulfill this training requirement against either land (most often) or water targets, or at specially prepared floating ship hulks during the occasional Sinking Exercise (SINKEX). F/A-18s will only rarely strafe into open ocean.

<u>MH-53, HH-60H, MH-60R/S, SH-60B/F Helicopters with Side Door-Mounted .50 cal and 7.62 mm Machine Guns</u>

Basic Phase (Unit Level Training) Scenario

Typically, a single helicopter will carry several air crewmen needing gunnery training and fly at an altitude between 50 ft to 100 ft in a 300 ft racetrack pattern around an at-sea target. Each gunner will expend about 200 rounds of .50 cal and 800 rounds of 7.62 mm ordnance in each exercise. The target is normally a non-instrumented floating object such as an expendable smoke float, but may be a remote controlled speed boat or jet ski type target if available. Gunners will shoot special target areas or at towed targets when using a remote controlled target to avoid damaging them. The exercise lasts about 1 hour.

Integrated and Sustainment Phase Training Scenarios

Typically do not differ from the Basic Phase Scenario.

Training Considerations

HH-60H, MH-60S, and SH-60F have a mission to support NSW operations, so they will also train with embarked NSW personnel. NSW personnel use .50 cal, 7.62 mm, and hand-held weapons firing 40 mm grenades during this exercise.

Local Training Considerations

GUNEX (A-S) operations are conducted by rotary-wing aircraft against stationary targets (FAST and smoke buoy). Rotary-wing aircraft involved in this operation would use either 7.62mm or .50 caliber door-mounted machine guns. Interviews with HSC-25 (MH-60S) indicate that GUNEX (A-S) training occurs frequently in the MIRC Offshore Areas other than W-517.

Anti-Submarine Warfare (ASW) - Helicopters, Maritime Patrol Aircraft, Surface Ships, and Submarines

Maritime patrol aircraft, helicopters, surface ships, and submarines search for threat submarines with active and passive sonar and sonobuoys, develop a firing solution and use torpedoes to attack and destroy the threat submarine.

<u>ASW Mission</u>

The search and attack mission may be conducted by individual platforms or in various combinations of all four platform types, but the ASW prosecution will go through six specific phases to complete the search and attack mission:

- Search - As naval units move from one location to another they employ their available sensors and tactics of systematic reconnaissance to find the anticipated threat along their route or within a defined ocean area.

- Detect - The initial result of a sensor's perception of an object of possible interest, but the object's identification still needs to be determined.
- Classify - The determination that the object that has been detected by the sensor is a probable submarine.
- Localize - Tactics are used to determine the exact location of the probable submarine.
- Track - A series of sensor localizations over a period of time creates a path from which the sensor operator may determine the probable submarine's course and speed. This information is used to create a firing solution, e.g. where to send the torpedo.
- Neutralize - A torpedo is launched toward the position of the probable submarine and it is destroyed.

ASW Sensors

Hull Mounted Sonar:

- Surface ships have hull mounted sonar with both active and passive capabilities. The CG and DDG classes have the AN/SQS-53 and the FFG class has the AN/SQS-56. Both are mid-frequency active sonar.
- AN/BQQ-5 is mid-frequency active and passive bow-mounted sonar, including a medium frequency active capability, used by SSN 688 class submarines.
- AN/BQQ-6 is a passive only sonar used by the Ohio class SSBN submarines
- AN/BQQ-10 is sonar system upgrade to the older AN/BQQ-5 and BQQ-6 systems, and has been installed or has been scheduled for integration onto Los Angeles, Seawolf, Virginia (AN/BQQ-10(V4) model), Ohio and SSGN-class submarines. It integrates and improves towed array, hull array, sphere array, and other ship sensor processing while enhancing fidelity. Since program inception in 1998, AN/BQQ-10 systems have been installed on over 40 submarines.

Towed Array Sonar: this is a passive sonar system that is simply a long cable full of microphones that is towed behind the ship. Passive sonar is a listening device that uses hydrophones to receive, amplify, and process underwater sounds. The advantage of passive sonar is that it places no sounds in the water, so it does not reveal the location of the ship towing the sonar.

- AN/SQR-19 is the towed array sonar used by surface ships (CG, DDG, and FFG).
- TB-23 and TB-29 are towed arrays used by SSN.

Dipping Sonar:

- AN/AQS-22 Airborne Low Frequency Sonar (ALFS) is an active and passive sonar system used by the MH-60R helicopter. The active sonar operates in the mid-frequency range.
- AN/AQS-13 is an active sonar system used by the SH-60F helicopter. The sonar is deployed on a 1,575 ft cable while the helicopter hovers about 60 ft above the water.

Sonobuoys: can be either active or passive. Multiple sonobuoys are deployed at one time in different patterns depending on the tactical situation. The sonobuoys sink after their battery is exhausted.

- Active sonobuoys transmit electronic mid-frequency sound waves (sonar) that reflect off the target submarine and are received by the sonobuoy.
- Passive sonobuoys only receive target submarine noise signals transmitted through the water from various equipments in the submarine, such as engine noise.
- Explosive Echo Ranging (EER) and the Improved Explosive Echo Ranging (IEER sonobuoy systems consist of two separate sonobuoys employed together to locate a target submarine. One sonobuoy is an active "explosive" buoy that creates an acoustic sound source from the explosion of 4.2-lbs of high explosives. The active buoy contains two 4.2-lb sources that are detonated at separate times to extend the life of the buoy. The other sonobuoy is an air deployable active

receiver (ADAR) passive buoy placed several miles away from the active buoy. It receives echoes reflected from the target submarine that were created by the active buoy's explosive source.

- Acoustic Extended Echo Ranging (AEER) sonobuoy (AN/SSQ-125). The AEER system uses the same ADAR sonobuoy as the EER/IEER acoustic receiver and is used for a large area ASW search capability in both shallow and deep water. However, instead of using explosives as an impulsive source for the active acoustic wave, the AEER system uses a battery powered (electronic) acoustic source. AAER is intended to replace the EER/IEER's use of explosives and is scheduled to enter the fleet in 2011.

Radar is used by most ASW capable units to watch for periscopes and other masts that the submarine may expose.

Magnetic Anomaly Detector (MAD) is used by MPA and the SH-60B helicopter, and is a passive receiver used to detect natural and manmade differences in the Earth's magnetic field. MAD sensor operation is similar in principle to the metal detector used by treasure hunters on beaches. When the MAD sensor passes over or very near to a submarine, the submarine's disturbance of the Earth's magnetic field is detected, and the submarine's position is pinpointed.

ASW Platforms

Aircraft:

- The P-3C and P-8A Maritime Patrol Aircraft are land based, long range, fixed-winged aircraft. Their ASW sensors include radar, Magnetic Anomaly Detector (MAD), and up to 84 active, EER, and passive sonobuoys. Of these sensors, only sonobuoys enter the water.
- The SH-60B, operates from cruisers, destroyers, and frigates, has a search radar, MAD, and carries 25 active and passive sonobuoys, but usually drops only 8-14 in a given exercise.
- The SH-60F operates from aircraft carriers and employs a search radar, active or passive dipping sonar rather than MAD, and carries only 14 active or passive sonobuoys.
- The MH-60R combines the capabilities of the SH-60B and SH-60F, with search radar and active and passive sonobuoys, and employs a new, low frequency, active and passive dipping sonar, the AN/AQS-22 Airborne Low Frequency Sonar (ALFS).

Surface Ships:

- Cruisers (CG)
- Guided Missile Destroyers (DDG)
- Guided Missile Frigates (FFG).

Ship ASW sensors include passive hull-mounted and towed array sonar that put no acoustic energy in the water, active hull-mounted mid-frequency sonar, and SH-60B or MH-60R helicopters if the specific ship has a helicopter embarked.

Submarines:

- Attack Submarine (SSN)
- Guided Missile Submarine (SSGN)
- Ballistic Missile Submarine (SSBN).

The SSN is the principal ASW attack submarine, but each class submarine must train to the ASW mission. Submarine ASW sensors are principally passive hull-mounted and towed array sonar, and secondarily, hull-mounted mid-frequency active sonar, which is seldom used.

ASW Ordnance

ASW platforms use the following ordnance to neutralize enemy submarines:

Lightweight Torpedoes: The navy is phasing out the MK-46 torpedo and is expected to completely replace it with the MK-54 by 2012. The MK-54 has improved guidance and warhead systems over the MK-46. Helicopters, MPA, and surface ships all use variants of these torpedoes. Although the different launching methods will involve different supporting expendables (parachutes, rocket boosters, nose caps, etc.), the torpedo is the same once it has entered the water. There are typically two types of torpedoes used in exercises:

- Practice Torpedo Exercise Shape. The recoverable exercise torpedo (REXTORP) is just a torpedo shape with no internal propulsion or guidance mechanisms that allows crews to practice loading and launching the torpedo.
- Exercise Torpedo (EXTORP). The EXTORP is a recoverable, functional torpedo with an inert exercise warhead that contains data collection instrumentation. This exercise torpedo will actually function just like a real torpedo, using active and passive acoustic homing to attack the target, but turn away so as not-to-hit the target. Once the EXTORP is recovered, the instrumentation may be accessed at the land based torpedo shop to provide data that will give an indication that the torpedo would have hit the target or not.

REXTORPS are used more often than EXTORPS because of a number of exercise constraints, including higher costs and safety requirements, on the use of EXTORPS.

Heavyweight Torpedo: The MK-48 exercise torpedo is used only by submarines (SSN, SSGN, SSBN) and has both an anti-surface and Anti-Submarine capability. It is wire guided (command controlled from the submarine) and has an active and passive homing capability. This torpedo is most frequently used on instrumented underwater tracking ranges to ensure the best training feedback to submarine crews. Use of the exercise MK-48 requires special recovery support assets such as special helicopters or vessels equipped for their recovery, which also requires that they be used only during daylight.

ASW Targets and Pingers

ASW training targets are used to simulate target submarines. They are equipped with one or a combination of the following devices: (1) acoustic projectors emanating sounds to simulate submarine acoustic signatures; (2) echo repeaters to simulate the characteristics of the echo of a particular sonar signal reflected from a specific type of submarine; and (3) magnetic sources to trigger magnetic detectors.

There are three principal targets used in ASW training exercises:

- One or more submarines is the most desirable target because it provides the most realistic training and can be augmented to simulate typical threat submarines that could be encountered.
- MK-39 Expendable Mobile ASW Training Target (EMATT). This expendable target is small enough to be launched by hand from a surface ship, aircraft or helicopter using the target. It provides a sound source for passive tracking, or a return echo to active sonar.
- MK-30 Mobile ASW Target. This target is principally used only on instrumented ranges as it requires range support for launching and recovery. It too provides a sound source for passive tracking, or a return echo to active sonar. The MK 30 target is a torpedo-like, self-propelled, battery powered underwater vehicle capable of simulating the dynamic, acoustic, and magnetic characteristics of a submarine. The MK-30 is 21 inches in diameter and 20.5 feet in length. These targets are launched by aircraft and surface vessels and can run approximately four hours dependent on the programmed training scenario. The MK 30 is recovered after the exercise for reconditioning and subsequent reuse. The MK 30 has no discharges into the environment.

Any of these targets may be tasked within their capability to be non-evasive, operate on a specified track, make simple course or depth maneuvers, or to be fully evasive depending on the state of training of the ASW unit and the training objectives to be achieved. The MK-39 and MK-30 targets may be used for exercise torpedo firings. Some live submarines may also be used as exercise torpedo targets, but there are special requirements and special authorizations required before a live submarine can be assigned as a target for an inert torpedo firing.

MK 84 range pingers, used in association with the Portable Undersea Tracking Range, are active acoustic devices that allow ships, submarines, and target simulators to be tracked by means of deployed hydrophones. The signal from a MK 84 pinger is very brief (15 milliseconds) with a selectable frequency at 9.24 kHz, 12,93 kHz, 33.25 kHz, or 36.95 kHz and a source level of approximately 190 dB SPL.

ASW Basic Training Scenarios

It is important to understand that, in most cases, all phases of ASW prosecution (search, detection, classification, localization, tracking, and neutralization) are done in both the ASW Tracking Exercise (TRACKEX) and ASW Torpedo Exercise (TORPEX); the difference is the amount of time spent in the first five phases and the last. In the ASW TRACKEX, the goal is training in the search, detection, classification, localization, and tracking process, while the goal of the ASW TORPEX is to proceed quickly through these first five phases and focus on neutralization of the target through the launching of a torpedo. Besides the training goal, the principal factors that drive this timing are usually the battery life of the torpedo target and the torpedo recovery support requirements, which include a low sea state and several hours of daylight to ensure recovery of the exercise torpedo before sunset. No torpedo is fired during an ASW TRACKEX unless it is coupled with an ASW TORPEX.

ASW Integrated and Sustainment Phase Training Scenarios

These scenarios involve coordinated ASW operations where multiple ships, helicopters, and maritime patrol aircraft operate together to prosecute an ASW threat and defend the elements of the strike group. The combination of a variety of sensors and the capability of the aircraft to cover large areas quickly and employ ASW weapons at greater ranges is a significant advantage over single platform operations.

Coordinated operations may also include a friendly submarine as part of the force. While this added sensor is extremely valuable, it adds complications to the exercise to ensure that a weapon is not dropped on the friendly submarine.

The goal of exercises conducted in these phases is to gain the experience of working with additional forces and coordinating several similar and dissimilar platforms to work together with information provided from other units to destroy the threat submarine.

One or more live submarines will typically be used as the threat for these phases. A phase could last from four to six hours during unit or sustainment training or from 12 to 16 hours or longer during major integrated ASW exercises.

Training Considerations

Basic Phase ASW TRACKEXs are preferred to be conducted on an Undersea Warfare Training Range (USWTR), but the scarcity of USWTRs, distances from homeports to those that do exist, and exigencies of deployment schedules conspire to ensure that most do not occur over an USWTR.

Integrated and Sustainment Phase ASW TRACKEXs rarely occur over USWTRs since major fleet training exercises require ocean areas much larger than an USWTR.

Anti-Submarine Warfare Tracking Exercise–Helicopter (ASW TRACKEX-Helo)

Helicopters use their sensors to search, detect, classify, localize and track a threat submarine with the goal of determining a firing solution that could be used to launch a torpedo and destroy the submarine.

Table D-17: Anti-Submarine Warfare Tracking Exercise–Helicopter (ASW TRACKEX-Helo)

Range Activity	Platform	System or Ordnance	No Action Alternative	Alternative 1	Alternative 2	Location
ANTI SUBMARINE WARFARE (ASW)						
ASW TRACKEX (HELO)	SH-60B, SH-60F SUB/ MK-30/ EMATT	AQS-22 DICASS	9 Events; 2 hours/helo	18 Events; 2 hours/helo	62 Events; 2 hours/helo	PRI: W-517 SEC: MI Maritime, >3 nm from land

SH-60B with Sonobuoys and MAD

SH-60F or MH-60R with Sonobuoys and Dipping Sonar

Basic Phase (Unit Level Training) Scenario

A single helicopter will typically drop its sonobuoys from an altitude below 3,000 ft into specific patterns designed for both the anticipated threat submarine and the specific water conditions. These patterns will cover many different size areas, depending on these two factors. Passive sonobuoys will be used first, so that the threat submarine is not alerted to the fact that someone is searching for him. Active buoys will be used as required either to locate extremely quiet submarines or to further localize and track submarines previously detected by passive buoys. The use of EER sonobuoys is similar to that of other sonobuoys except for how the field is positioned, the tactics of which are classified. The helicopter will typically operate below 3,000 ft during the entire operation, going to about 1,500 ft to monitor buoys already dropped.

The dipping sonar is employed from an altitude of about 50 ft after the search area has been narrowed from the initial passive sonobuoy search. The passive sonar from the MH-60R is used before its active mode or before the active sonar from the SH-60F is used, just as the passive sonobuoys are used before the active sonobuoys.

As the location of the submarine is further narrowed, MAD is used by the SH-60B to further confirm and localize the target's location.

The target for this exercise is either an EMATT or live submarine and may be either non-evading and assigned to a specified track, or fully evasive depending on the state of training of the helicopter. A TRACKEX-Helo usually takes one to two hours.

Integrated and Sustainment Phase Training Scenarios

Integrated and sustainment phase scenarios do not typically differ from the description of the unit level phase scenario, except that additional helicopters, maritime patrol aircraft, or surface ships may participate together, using their sensors and weapon capabilities, as a coordinated operation.

Anti-Submarine Warfare Tracking Exercise–Maritime Patrol Aircraft (ASW TRACKEX-MPA)

MPA use their sensors to search, detect, classify, localize and track a threat submarine with the goal of determining a firing solution that could be used to launch a torpedo and destroy the submarine.

Table D-18: Anti-Submarine Warfare Tracking Exercise-Maritime Patrol Aircraft

Range Activity	Platform	System or Ordnance	No Action Alternative	Alternative 1	Alternative 2	Location
ANTI SUBMARINE WARFARE (ASW)						
ASW TRACKEX (MPA)	FIXED WING MPA SUB/ MK-30/ EMATT	DICASS EER/IEER/AEER	5 Events; 4 hours/MPA	8 Events; 4 hours/MPA	17 Events; 4 hours/MPA	PRI: W-517 SEC: MI Maritime, >3 nm from land

<u>**MPA with Sonobuoys and MAD**</u>

Basic Phase (Unit Level Training) Scenario

A single MPA drops its sonobuoys from an altitude below 3,000 ft into specific patterns designed for both the anticipated threat submarine and the specific water conditions. These patterns will cover many different size areas, depending on these two factors. Passive sonobuoys will be used first, so that the threat submarine is not alerted to the fact that someone is searching for it. Active buoys will be used as required either to locate extremely quiet submarines, or to further localize and track submarines previously detected by passive buoys. The use of EER sonobuoys is similar to that of other sonobuoys except for how the field is positioned, the tactics of which are classified. While the MPA will typically operate below 3,000 ft to drop sonobuoys, perhaps as low as 1,000 ft, it will climb to several thousand feet and fly in a pattern over the buoy field to best monitor the buoys. A MPA sonobuoy field pattern will typically be much larger than a helicopter pattern, as the MPA can carry and deploy more buoys than a helicopter, and can monitor 31 buoys at one time. The higher altitude allows monitoring the buoys over a much larger search pattern area.

MAD is used principally during the localization phase to further confirm a more exact target location moments before weapons launch, although there are no weapons used in this tracking exercise. The MPA will fly within a few hundred feet above the best estimated position of the threat submarine as close proximity is required to best employ MAD.

The target for this exercise is either an EMATT or live submarine and may be either non-evading and assigned to a specified track or fully evasive depending on the state of training of the MPA. A TRACKEX-MPA usually takes two to four hours.

Integrated and Sustainment Phase Training Scenarios

Integrated and sustainment phase scenarios do not typically differ from the description of the unit level phase scenario, except that additional helicopters, MPA, or surface ships may participate together, using their sensors and weapon capabilities, as a coordinated operation.

Anti-Submarine Warfare Tracking Exercise–Surface (ASW TRACKEX-Surface)

Surface ships use their sensors to search, detect, classify, localize and track a threat submarine with the goal of determining a firing solution that could be used to launch a torpedo and destroy the submarine.

Table D-19: Anti-Submarine Warfare Tracking Exercise-Surface (ASW TRACKEX-Surface)

Range Activity	Platform	System or Ordnance	No Action Alternative	Alternative 1	Alternative 2	Location
ANTI SUBMARINE WARFARE (ASW)						
ASW TRACKEX (SHIP)	CG/ DDG / FFG SUB/ MK-30/ EMATT	SQS-53C/D SQS-56	10 Events; 4 hours/ship	30 Events; 4 hours/ship	60 Events; 4 hours/ship	PRI: W-517 SEC: MI Maritime, >3 nm from land

<u>CG, DDG, FFG with Hull Mounted and Towed Array Sonar</u>

Basic Phase (Unit Level Training) Scenario

A single surface ship will operate between about 5 and 15 kts while employing its hull mounted and/or towed array sonars. Passive or active sonar will be employed depending on the type of threat submarine, the tactical situation, and sonar range of the day calculations, as determined by varying water conditions. Active sonar transmits at varying power levels, pulse types, and intervals, while passive sonars listen for noise emitted by the threat submarine. Passive sonar is typically employed first so as not to alert the threat submarine, followed by active sonar, if required, to determine a more exact location of the target. Active sonar may be employed during the search phase against an extremely quiet submarine or in situations where the water conditions do not support good passive reception. The surface ship will approach the threat submarine to between 10 nm and 1,000 yards during training.

The target for this exercise is either an EMATT or live submarine and may be either non-evading and assigned to a specified track or fully evasive depending on the state of training of the ship. There is no torpedo fired in this exercise. An ASW TRACKEX-Surface usually lasts two to four hours.

Integrated and Sustainment Phase Training Scenarios

Integrated and sustainment phase scenarios do not typically differ from the description of the unit level phase scenario, except that the surface ship will usually be working in conjunction with additional helicopters, MPA, or surface ships, using their sensors and weapon capabilities together in a coordinated operation.

Anti-Submarine Warfare Tracking Exercise–Submarine (ASW TRACKEX-Sub)

Submarines use their sonar sensors to search, detect, classify, localize and track the threat submarine with the goal of developing a firing solution that could be used to launch a torpedo and destroy the threat submarine.

Table D-20: Anti-Submarine Warfare Tracking Exercise-Submarine (ASW TRACKEX-Sub)

Range Activity	Platform	System or Ordnance	No Action Alternative	Alternative 1	Alternative 2	Location
ANTI SUBMARINE WARFARE (ASW)						
ASW TRACKEX (SUB)	SSN; SSGN MK-30	BQQ	5 Events; 4 hours /sub	10 Events; 4 hours /sub	12 Events; 4 hours /sub	PRI: Guam Maritime, >3 nm from land SEC: W-517

<u>SSN, SSGN, SSBN with Hull Mounted and Towed Array Sonar</u>

Basic Phase (Unit Level Training) Scenario

A single submerged submarine operates at slow speeds and various depths while using its hull mounted and/or towed array sonar to search, detect, classify, localize, and track the submerged threat submarine. During submarine versus submarine TRACKEXs, passive sonar is used almost exclusively. Active sonar use is very rare because it reveals the tracking submarine's presence to the target submarine.

Typically, this exercise is conducted by two submarines, but in the event a second submarine is not available, a MK-30 Mobile ASW Target or EMATT may also be used as a target. If feasible this exercise may be conducted on an USWTR so that both submarines and targets can be tracked by the range and the submarine crews can be debriefed at the completion of the exercise. The debrief adds to a full understanding of what actually occurred during the exercise and improves the quality of the training received. There is no torpedo fired in this exercise. A TRACKEX-Submarine usually lasts two to four hours.

Integrated and Sustainment Phase Training Scenarios

Integrated and sustainment phase scenarios do not typically differ from the description of the unit level phase scenario, except that two or more friendly submarines or one submarine and a surface ship may operate together to prosecute the threat submarine.

Anti-Submarine Warfare Torpedo Exercise–Helicopter (ASW TORPEX-MPA/Helo)

Helicopters or MPA deliver torpedoes against threat submarines with the goal of destroying the submarine.

Table D-21: Anti-Submarine Warfare Torpedo Exercise-Helicopter (ASW TORPEX-MPA/Helo)

Range Activity	Platform	System or Ordnance	No Action Alternative	Alternative 1	Alternative 2	Location
ANTI SUBMARINE WARFARE (ASW)						
ASW TORPEX (MPA / HELO)	MPA / SH-60B/F, SUB/ MK-30/ EMATT TRB / MH-60S/ RHIB	AQS-22 / DICASS REXTORP	0	4 events; 2 hours	8 events; 2 hours	PRI: Guam Maritime, >3 nm from land SEC: W-517

SH-60B, SH-60F, or MH-60R or MPA with MK-46 or MK-54 REXTORP or EXTORP

Basic Phase (Unit Level Training) Scenario

A single helicopter or MPA uses its sensors to localize and track the threat submarine and develop a firing solution. The aircraft then flies to a drop point about 150 ft above the water and releases the torpedo. Torpedoes are only released during the day and are recovered before sunset. A helicopter is typically based on a CG, DDG, or FFG class ship and a helicopter or MPA may conduct this range operation in conjunction with a ship's tracking or torpedo exercise. This exercise typically lasts one to two hours. It follows the same initial procedures of an ASW TRACKEX, but quickly advances into the neutralization phase with the actual drop of a REXTORP or EXTORP. The target is typically an EMATT or MK-30 target.

Anti-Submarine Warfare Torpedo Exercise–Surface (ASW TORPEX-Surface)

Surface ships deliver torpedoes against threat submarines with the goal of destroying the submarine.

Table D-22: Anti-Submarine Warfare Torpedo Exercise-Surface (ASW TORPEX-Surface)

Range Activity	Platform	System or Ordnance	No Action Alternative	Alternative 1	Alternative 2	Location
ANTI SUBMARINE WARFARE (ASW)						
ASW TORPEX (SHIP)	CG/ DDG / FFG SUB/ MK-30/ EMATT TRB / MH-60S/ RHIB	SQS-53C/D SQS-56 REXTORP	0	3 Events; 4 hours	6 Events; 4 hours	PRI: Guam Maritime, >3 nm from land SEC: W-517

<u>CG, DDG, or FFG with MK-46 or MK-54 REXTORP or EXTORP</u>

Basic Phase (Unit Level Training) Scenario

A single surface ship uses its sensors to localize and track the threat submarine and develop a firing solution. The ship then proceeds to a position where the torpedo can be launched from either the surface vessel torpedo tube (SVTT) or the vertical launch rocket thrown torpedo (RTT) cell. The RTT is the same torpedo as the tube launched torpedo once it enters the water, as previously discussed, but it is delivered to the water entry point by a rocket booster. Torpedoes are only released during the day and are recovered before sunset.

This exercise typically lasts about two to four hours. It follows the same initial procedures of an ASW TRACKEX-Surface, but quickly advances into the neutralization stage with the actual launch of a REXTORP or EXTORP. The target is typically an EMATT or MK-30 target.

Anti-Submarine Warfare Torpedo Exercise–Submarine (ASW TORPEX-Sub)

Submarines deliver torpedoes against threat submarines with the goal of destroying the threat submarine.

Table D-23: Anti-Submarine Warfare Torpedo Exercise-Submarine (ASW TORPEX-Sub)

Range Activity	Platform	System or Ordnance	No Action Alternative	Alternative 1	Alternative 2	Location
ANTI SUBMARINE WARFARE (ASW)						
ASW TORPEX (SUB)	SSN; SSGN MK-30 TRB / MH-60S	BQQ MK-48 EXTORP	5 Events; 4 hours	10 Events; 4 hours	12 Events; 4 hours	PRI: Guam Maritime, >3 nm from land SEC: W-517

SSN, SSGN, SSBN with MK-48 Exercise Torpedo

Basic Phase (Unit Level Training) Scenario

A single submerged submarine uses its sensors to localize and track the threat submarine and develop a firing solution. The submarine then proceeds to a position where the torpedo can be launched up to a maximum range of 35,000 yards from the threat submarine. Torpedoes are only released during the day and are recovered before sunset.

This exercise typically lasts one to two hours. It follows the same initial procedures of an ASW TRACKEX-Sub but quickly advances into the neutralization stage with the actual launch of a MK-48 exercise torpedo. The target is typically a MK-30 Mobile ASW Target or an EMATT.

Training Considerations

This exercise is ideally conducted on an instrumented range, but it may be conducted in other operating areas depending on training requirements and available assets. The MK-48 exercise torpedo requires recovery support assets such as special helicopters or vessels equipped for their recovery.

Air Combat Maneuver (ACM)

Strike fighter aircraft perform intricate flight maneuvers to achieve a gun or missile firing position from which an attack can be made on a threat aircraft with the goal of destroying the adversary aircraft.

ACM is the general term used to describe an air-to-air (A-A) event involving two or more aircraft. These aircraft may be similar or dissimilar. Aircraft are considered similar if they are of the same aircraft type and model. For example, an F/A-18C is similar to an F/A-18E, whereas an F/A-18 and an F-15 are dissimilar.

Unit Level ACM training consists of three levels: Basic Fighter Maneuvering (BFM), intermediate level Offensive Counter Air (OCA), and Defensive Counter Air (DCA) training. No live-weapons are fired during ACM operations.

BFM: during BFM, two aircraft (one vs. one) will engage in offensive and defensive maneuvering against each other.

OCA and DC: during OCA or DCA training, three or more aircraft (one vs. two, two vs. two, or three vs. one) will engage in offensive and defensive maneuvering. Participating aircraft will be separated at the start by distances up to 50 nm. During OCA training, a force of two or more aircraft will attempt to establish and maintain air superiority over a defined battle space by defeating a force of defending aircraft. During DCA training, a force of two or more aircraft will attempt to retain air superiority over a defined battle space by defeating a force of aggressor aircraft. Unit level OCA and DCA training, which is a precursor to joint and combined integrated range operations, involves high airspeeds (from high subsonic to supersonic) and rapidly changing aircraft altitudes and attitudes.

Table D-24: Air Combat Maneuver (ACM)

Range Activity	Platform	System or Ordnance	No Action Alternative	Alternative 1	Alternative 2	Location
AIR WARFARE (AW)						
AIR COMBAT MANUEVERS (ACM)	FA-18; AV-8B; F-15; F16.	Captive Air Training Missile (CATM) or Telemetry Pod	360 sorties of 2-4 aircraft per sortie	720 sorties of 2-4 aircraft per sortie	840 sorties 2-4 aircraft per sortie	PRI: W-517 SEC: MI Maritime, >12nm from land; ATCAAs

Fighter Aircraft with Captive Carry Training Missiles (CATM-9)

Basic Phase (Unit Level Training) Scenario

Typically two aircraft, operating from 5,000 to 30,000 ft, begin their maneuvers from a separation distance of 2 to 3 nm and, throughout an "engagement," will normally not separate beyond visual range (6 to 8 nm). Aircraft airspeeds will range from very low (less than 100 kts) to high subsonic (less than 600 kts). Their maneuvers will be continuous proactive and reactive changes in aircraft attitude, altitude, and airspeed to gain advantage over the adversary aircraft, resulting in its simulated destruction from guns or missiles. Maneuvers will last for about one hour.

The training scenario builds through several separate basic levels as the pilot becomes more experienced and will include:

- Defensive fighter maneuvers - one vs. one adversary is described above
- High aspect fighter maneuvers - one vs. one adversary that starts from a offensive, defensive or neutral position
- Dissimilar fighter maneuvers - one vs. one adversary of a different type of adversary aircraft
- Section fighter maneuvers - two vs. one adversary or more.

Integrated and Sustainment Phase Training Scenarios

Typically not conducted during these phases; these scenarios do not normally have adversary aircraft operating within visual range of friendly aircraft.

Training Considerations

The preferred ACM training location is on a Tactical Aircrew Training System (TACTS) Range located within a Warning Area or Restricted Airspace; TACTS is not available in the MIRC. TACTS equipped range airspaces are designed to keep other aircraft clear of the area where military aircraft are conducting operations and thereby allow safe operations. The TACTS range has the capability to precisely track and record the location of aircraft conducting maneuvers on the range. This capability provides excellent data for feedback that is used to debrief the aircraft crews after their training. The TACTS system is being replaced by a new system called Tactical Combat Training System (TCTS); Carrier Air Wing Five, stationed in Japan, is scheduled to receive TCTS. It essentially provides the same service, but it can more precisely locate each aircraft on the range, is portable and organic to the air wing, and has a longer range capability than TACTS. The training aircraft must still conduct their training within a Warning or Restricted Area, but more of the area is now available because of the new technology available in TCTS.

Missile Exercise (Air-to-Air) (MISSILEX [A-A])

Strike fighter aircraft attack a simulated threat target aircraft with its air-to-air missile with the goal of destroying the other aircraft.

Table D-25: Missile Exercise (Air-to-Air) (MISSILEX [A-A])

Range Activity	Platform	System or Ordnance	No Action Alternative	Alternative 1	Alternative 2	Location
AIR WARFARE						
MISSILEX / GUNEX Air-to-Air	FA-18; EA-18; AV-8B. TALD tgt.	AIM-7 Sparrow (Non Explosive). 20mm or 25 mm cannon.	4 sorties (2-4 aircraft) (4 missiles; 1,000 rounds)	6 sorties (2-4 aircraft) (6 missiles; 1,500 rounds)	8 sorties (2-4 aircraft) (8 missiles; 2,000 rounds)	PRI: W-517 SEC: MI Maritime, >12nm from land; ATCAAs
		AIM-9 Sidewinder (HE)/AIM-120 (HE or Inert). 20mm or 25 mm cannon.	4 sorties (2-4 aircraft) (4 missiles; 1,000 rounds)	6 sorties (2-4 aircraft) (6 missiles; 1,500 rounds)	8 sorties (2-4 aircraft) (8 missiles; 2,000 rounds)	

F/A-18 with AIM-7 Sparrow; AIM-9 Sidewinder; or AIM-120 AMRAAM (Live or Inert)

EA-18G with AIM-120 AMRAAM (Live or Inert)

Basic Phase (Unit Level Training) Scenario

A flight of two aircraft operating between 15,000 to 25,000 ft and at a speed of about 450 kts will approach a target from several miles away and, when within missile range, will launch their missile against the target. Approximately half of the missiles have live warheads and about half have an inert telemetry head package. The missiles fired are not recovered.

The target is an unmanned aerial target drone (BQM-34; BQM-74) or Tactical Air-Launched Decoy (TALD). BQM targets deploy parachutes, float on the surface of the water, and are recovered by boat. TALDs are expended. The exercise lasts about one hour, is conducted in a warning Area at sea outside of 12 nm and well above 3,000 ft

Integrated and Sustainment Phase Training Scenarios

Typically do not differ from the Basic Phase Scenario.

Training Considerations

Range operations conducted with “captive carry” missiles (missiles that are not released from the aircraft) are documented under Air Combat Maneuver. Only live or inert missiles that are actually fired from the aircraft are documented under this range operation heading.

Local Training Considerations

In the MIRC this event refers to training operations in which air-to-air missiles are fired from aircraft against unmanned aerial target drones, gliders, or flares. The missiles fired are not recovered.

Electronic Combat Operations (EC OPS); Chaff and Flare Exercises

Aircraft, surface ships, and submarines attempt to control critical portions of the electromagnetic spectrum used by threat radars, communications equipment, and electronic detection equipment to degrade or deny the enemy's ability to defend its forces from attack and/or recognize an emerging threat early enough to take the necessary defensive actions.

EC OPS can be active or passive, offensive or defensive.

Active EC OPS use radio frequency (RF) transmissions in the 2-12 gigahertz frequency spectrum to conduct jamming and deception.

- Jamming bombards a radio or radar receiver with sufficient RF energy to cause the internal automatic gain setting of the receiving equipment to adjust the signal-to-noise threshold setting downward to a point where the desired RF return (for example, a radio voice, datalink transmission, or a target's radar return) is "lost" in the background noise of the RF spectrum.
- Electronic deception may generate false targets that appear to be real, thereby causing the recipient of the false targets to commit forces or weapons to attack those targets, and, in the process, not attack the real target. Another type of deception allows the defender to deny the attacker's weapon system from successfully acquiring and engaging a valid target.

Passive EC OPS use the enemy's electromagnetic transmissions to obtain intelligence about their operations and to recognize and categorize an enemy threat and take steps to defend against it.

Offensive EC OPS use active or passive installed EC systems against enemy search, EC, and weapons systems. Electronically, this process is active (overpowering enemy receiver systems) or passive (chaff) jamming.

Defensive EC OPS use active or passive installed EC systems in reaction to enemy threat systems. These installed EC systems are programmed to recognize an enemy threat signal and will automatically send a false return signal to the enemy threat system or dispense chaff and/or flares in immediate reaction to receiving an enemy threat signal. Missile, gun or search radar signals are common threat signals that can initiate an automatic response.

Navy units can conduct EC OPS training as stand alone events, but they are often embedded in other training events, such as fighting through enemy jamming to deliver ordnance on targets or ejecting chaff and flares in response to enemy missile threat radars.

Training ranges need an EC OPS training capability that can generate threat signals that will exercise the full range of every platform's EC capability and also be able to evaluate the effectiveness of both the equipment and operator's tactical responses to those signals.

EC OPS may also be categorized in several other areas where they may be combined with primary exercise being conducted. These other exercises include:

- HARMEX, destruction of enemy threat radars; non-firing exercises are included in this EC OPS category.
- Chaff Exercise, disruption of enemy threat search or guidance radars.
- Flare exercise, seduction of enemy threat missile guidance systems or infrared systems.

Ships, fixed-winged aircraft, and helicopters deploy chaff to disrupt threat targeting and missile guidance radars and to defend against an attack.

The chaff exercise trains aircraft in the use and value of chaff to counter an enemy threat. Chaff is a radar reflector material made of thin, narrow, metallic strips cut in various lengths to elicit frequency responses, which deceive enemy radars. Chaff is employed for a number of different tactical reasons, but the end goal is to create a target from the chaff that will lure enemy radar and weapons system away from the actual friendly platform.

Chaff may be employed offensively, such as before a major strike to "hide" inbound striking aircraft or ships, or defensively in reaction to being detected by an enemy targeting radar. Defensive chaff training is the most common exercise used for training both ships and aircraft. In most cases, the chaff exercise is training for the ship or aircraft that actually deploys the chaff, but it is also a very important event to "see" the effect of the chaff from the "enemy" perspective so that radar system operators may practice corrective procedures to "see through" the chaff jamming, so exercises are often designed to take advantage of both perspectives.

Chaff exercises are often conducted with flare exercises, as well as other exercises, rather than as a stand alone exercise.

Table D-26: Electronic Combat Operations (EC OPS); Chaff and Flare Exercises

Range Activity	Platform	System or Ordnance	No Action Alternative	Alternative 1	Alternative 2	Location
ELECTRONIC COMBAT						
CHAFF Exercise	SH-60; MH-60; HH-60; MH-53	RR-144A/AL	12 sorties (360 rounds)	14 sorties (420 rounds)	14 sorties (420 rounds)	PRI: W-517 SEC: MI Maritime, >12nm from land; ATCAAs
	FA-18; EA-18; AV-8B; MPA; EA-6	RR-144A/AL	16 sorties (160 rounds)	32 sorties (320 rounds)	48 sorties (500 rounds)	
	F-15; F-16; C-130	RR-188	150 sorties (1,500 rounds)	500 sorties (5,000 rounds)	550 sorties (5,500 rounds)	
	CG, DDG, FFG, LHA, LHD, LPD, LSD	MK 214 (seduction); MK 216 (distraction)	12 (72 canisters)	16 (90 canisters)	20 (108 canisters)	

Table D-26: Electronic Combat Operations (EC OPS); Chaff and Flare Exercises (Continued)

Range Activity	Platform	System or Ordnance	No Action Alternative	Alternative 1	Alternative 2	Location
ELECTRONIC COMBAT (Continued)						
FLARE Exercise	SH-60; MH-60; HH-60; MH-53	MK 46 MOD 1C; MJU-8A/B; MJU-27A/B; MJU-32B; MJU-53B; SM-875/ALE	12 sorties (360 flares)	14 sorties (420 rounds)	14 sorties (420 rounds)	PRI: W-517 SEC: MI Maritime, >12nm from land; ATCAAs
	FA-18; EA-18; AV-8B; MPA; EA-6		16 sorties (160 rounds)	32 sorties (320 rounds)	48 sorties (500 rounds)	
	F-15; F-16; C-130	MJU-7; MJU-10; MJU-206	4 sorties (1,500 rounds)	500 sorties (5,000 rounds)	550 sorties (5,500 rounds)	

<u>F/A-18C/E/F; EA-18G; E-2C; MPA; SH-60B/F; MH-60R/S; HH-60H; MH-53E with Defensive Chaff</u>

There are various types of chaff; the type used varies based on the anticipated threat frequencies to be countered. Typical chaff includes:

- AN/ALQ-190(V)1 - used by SH-60B/F and MPA. This canister is the size of a sonobuoy and can actually also be employed in the offensive role to create chaff corridors as well as decoy missiles and radars in the defensive role.
- RR-129A/AL - used by all naval airframes.
- RR-144A/AL - designed specifically for training and used by all naval airframes.
- RR-181/AL - used by SH-60B/F and MPA. This chaff can also be employed in the offensive role to create chaff corridors as well as decoy missiles and radars in the defensive role.

Basic Phase (Unit Level Training) Scenario

Aircraft detect electronic targeting signals from threat radars or missiles, dispense chaff, and immediately maneuver to defeat the threat. The chaff cloud deceives the inbound missile, and the aircraft clears away from the threat.

The chaff disperses with the winds over a wide area and will eventually settle in limited concentrations over the surrounding land or sea areas where it was dispensed.

Integrated and Sustainment Phase Training Scenarios

Typically do not differ from the Basic Phase Scenario.

CG, DDG, FFG, LCC, LHA, LHD, LPD, LSD with MK-214 or MK-216 Super Rapid Bloom Off-board Chaff (SRBOC) Defensive Chaff

Defensive chaff deployed from ships is typically MK-214 (Seduction Chaff) or MK-216 (Distraction Chaff) from the MK-36 SRBOC launcher. The specific type and amount of chaff deployed will depend on the specific tactical situation.

Basic Phase (Unit Level Training) Scenario

A surface ship detects an electronic targeting signal or the ship's search radar detects an inbound threat missile. Chaff rounds are fired automatically or manually, depending on the setting selected for the tactical situation, from the MK-36 Super Rapid Bloom Off-board Countermeasures (SRBOC) Chaff and Decoy Launching System, or other similar systems. The chaff forms a cloud that presents a ship size "target," forcing the inbound missile to make a choice between the chaff and the real ship. With the employment of additional countermeasure tactics, the ship may maneuver away from the cloud and cause the missile to choose the chaff "target."

The chaff disperses with the winds over a wide area and will eventually settle in limited concentrations over the surrounding sea areas where it was dispensed.

Integrated and Sustainment Phase Training Scenarios

Typically do not differ from the Basic Phase Scenario.

Training Considerations

The chaff exercise trains shipboard personnel in the use and value of chaff to counter an enemy threat. Chaff is a radar reflector material made of thin, narrow, metallic strips cut in various lengths to elicit frequency responses, which will deceive enemy radars. Chaff is employed for a number of different tactical reasons, but the end goal is to create a target from the chaff that will lure enemy radar and weapons system away from the actual friendly ship.

Local Training Considerations

Chaff Exercises train aircraft and/or shipboard personnel in the use of chaff to counter anti-ship and antiaircraft missile threats. Chaff is a radar confusion reflector, consisting of thin, narrow metallic strips of various lengths and frequency responses, which are used to reflect echoes to deceive radars. During a Chaff Exercise, the chaff layer combines maneuvering with deployment of multiple rounds of chaff to confuse incoming missile threats. In an integrated Chaff Exercise scenario, ships/helicopters/fixed wing craft will deploy ship and air launched rapid bloom offboard chaff in pre-established patterns designed to enhance missile defense. In FY03 Air Force C-130 aircraft conducted Chaff Exercises in W-517.

CG, DDG, FFG, LHA, LHD, LPD, LSD, CVN with SLQ-32

The SLQ-32 provides early warning, identification, and direction of threat targeting radars and weapon emitters to own ship systems that will engage hard kill weapons (e.g. CIWS), automatically disperse chaff and flare decoys, and use active electronic emissions to counter inbound missiles.

Basic Phase (Unit Level Training) Scenario

Surface ships detect and evaluate threat electronic signals from threat aircraft or missile radars, evaluate courses of action concerning the use of passive or active countermeasures, then use ship maneuvers and either chaff, flares, active electronic countermeasures or a combination of them to defeat the threat.

Integrated and Sustainment Phase Training Scenarios

Typically do not differ from the Basic Phase Scenario.

Training Considerations

Threat signals are commonly provided by a commercial air service Lear Jet with a threat signal simulator pod that flies an appropriate threat missile profile; this service is not available in the MIRC.

F/A-18C/D with ALQ-165 and F/A-18E/F with ALQ-214 Jamming System

The AN/ALQ-165 is an automated active deception jammer designed to contribute to the electronic self-protection of the host aircraft from a variety of air-to-air and surface-to-air radar threats.

The AN/ALQ-214 is an Integrated Defensive Electronic Countermeasures (IDECM) Radar Frequency Countermeasures system that uses autonomous active techniques that deny, disrupt, delay, and degrade missile launch and firing solutions from a variety of air-to-air and surface-to-air radar and infrared threats. This system includes an onboard radio frequency countermeasures system as well as the ALE-55 Fiber Optics Towed Decoy, which is trailed behind the aircraft at varying lengths.

Basic Phase (Unit Level Training) Scenario

The F/A-18 will typically fly well above 3,000 ft at about 400 kts toward the threat signal generators used by the training range. When a threat signal is received the pilot, he reacts to the enemy missile threats by maneuvering and employing autonomous active jamming against the threat search radars or missiles.

Integrated and Sustainment Phase Training Scenarios

Typically do not differ from the Basic Phase Scenario, except that it is employed during a major range event, at sea, and in conjunction with other friendly forces.

EA-18G with Active Jamming Systems

- AN/ALQ-218 Airborne Electronic Attack (AEA) Suite - capable of selective reactive and pre-emptive electronic jamming of enemy communications. It is designed to replace the AN/ALQ-99.
- AN/ALQ-99 Tactical Jamming System - provides jamming in support of strike or assault forces. It automatically detects and classifies an enemy's radar then automatically electronically jams the radar.
- AN/USQ-113 Communications Jamming System - used to jam enemy communications

Basic Phase (Unit Level Training) Scenario

The EA-18G supports strike aircraft by employing active jamming against threat search radars to mask the friendly inbound strike aircraft mission against threat antiaircraft weapons or command and control communication radios. Aircraft will typically fly at about 18,000 ft at about 400 kts in a racetrack pattern that will best support jamming the threat receivers.

Integrated and Sustainment Phase Training Scenarios

Typically do not differ from the Basic Phase Scenario, except that it is typically employed during a major range event where jamming could be employed during strike or assault missions planned against opposing shore targets.

Training Considerations

Areas where active jamming may be employed are limited in order not to interfere with commercial RF signals or reveal current jamming capabilities.

SSN/SSGN/SSBN with Passive Electronic Detection Systems

Basic Phase (Unit Level Training) Scenario

Submarines use passive electronic detection equipment to search for, identify, and locate threat radars and communication systems in an effort to identify the threat that faces friendly forces and provide their location to strike forces that can destroy the threat systems.

This is a completely passive training scenario, but realistic target threat signals in a realistic threat environment improves the quality of training for submarine crews.

Integrated and Sustainment Phase Training Scenarios

Typically do not differ from the Basic Phase Scenario, except that it is conducted during major range events where the submarine could interact with Strike Forces.

Bombing Exercise (Air-to-Ground) (BOMBEX [A-G])

Fixed-winged strike aircraft deliver bombs and rockets against land targets, day or night, with the goal of destroying or disabling enemy vehicles, infrastructure, and personnel.

Table D-27: Bombing Exercise (Air-to-Ground) (BOMBEX [A-G])

Range Activity	Platform	System or Ordnance	No Action Alternative	Alternative 1	Alternative 2	Location
STRIKE WARFARE (STW)						
BOMBEX (LAND)	FA-18; AV-8B; B-1; B-2; B-52; F-15; F-16; F-22; A-10	High Explosive Bombs ≤ 500 lbs	400 annually	500 annually	600 annually	FDM (R-7201)
		High Explosive Bombs: 750 / 1,000 lbs / 2,000 lbs	1,600 annually	1,650 annually	1,700 annually	
		Inert Bomb Training Rounds ≤ 2,000 lbs	1,800 annually	2,800 annually	3,000 annually	
		Total Sorties (1 aircraft per sortie):	1,000 sorties	1,300 sorties	1,400 sorties	

Unguided or Precision-guided Bombs

Unguided munitions: MK-76 and BDU-45 (inert training bombs); MK-80 series bomb (inert or live); MK-20 Cluster Bomb (inert or live).

Precision-guided munitions: Laser-guided bombs (LGB) (live or inert); Laser-guided Training Rounds (LGTR) (inert, but does contain an impact initiated spotting charge); Joint Direct Attack Munition (JDAM) (inert or live). JDAM is simply a GPS guidance kit that is attached to an unguided, typically a MK-80 series bomb, in the 500 to 2000 Lb range.

Basic Phase (Unit Level Training) Scenario

A flight of two aircraft will approach the target from an altitude of between 15,000 ft to less than 3,000 ft and, when on an established range, will usually establish a racetrack pattern around the target. The pattern is established in a predetermined horizontal and vertical position relative to the target to ensure that all participating aircraft follow the same flight path during their target ingress, ordnance delivery, target egress, and "downwind" profiles. This type of pattern is designed to ensure that only one aircraft will be releasing ordnance at any given time. The typical bomb release altitude is below 3,000 ft and within a range of 1,000 yards for unguided munitions; above 15,000 ft and may be in excess of 10 nm for precision-guided munitions. Laser designators from the aircraft dropping the bomb, a support aircraft, or ground support personnel are used to illuminate certified targets for use with lasers when using laser guided weapons. The average time for this exercise is about one hour.

Integrated and Sustainment Phase Training Scenarios

Typically involves a simulated strike scenario with a flight of four or more aircraft, with or without a designated opposition force (OPFOR). Participating aircraft attack the target using real-world tactics, which may require that several aircraft approach the target and deliver their ordnance, simultaneously, from several different altitudes and/or directions. An E-2 aircraft is typically involved in this exercise from a command and control perspective, and an EA-18G aircraft may provide electronic combat support in larger events.

Training Considerations

Strike fighter pilots can fulfill this training requirement against either a land or water target, but the land target is most common.

Unguided munitions: Usually conducted at land ranges with inert or live ordnance, or water ranges with grounded ship hulks available for targets. MK-76 and BDU-48 inert bombs are the most common weapon allocation.

Precision-guided munitions: The very large safety footprints of these bombs limit their employment to land ranges with sufficiently large controlled air space and safety zones, or at-sea during a Sinking Exercise (SINKEX). Each squadron's training allowance is very small (only one or two per year), severely limiting the total fleet-wide annual expenditure of these weapons.

The major difference between a BOMBEX (A-S) and BOMBEX (A-G) is related to targets. Ground targets may include any combination of fixed and mobile targets. Fixed targets may include a bull's eye of concentric rings and real or simulated wheeled vehicles, convoys, trains, aircraft, buildings, petroleum and oil storage areas, personnel silhouettes, and artillery and missile sites. Mobile targets include remote-controlled wheeled vehicles. Any ashore BOMBEX target may be actively or passively augmented to provide radar, infrared, or electronic signals, or support laser designation.

Feedback to participants is very important for this exercise and can include any combination of real-time and post-mission feedback from a Weapon Impact Scoring System (WISS) or instrumented range, real-time visual sighting by range observers or participating aircrews, and post-mission telephonic or facsimile debrief.

Local Training Considerations

BOMBEX (A-G) allows aircrews to train in the delivery of bombs and munitions against ground targets. The weapons commonly used in this training on FDM are inert training munitions (e.g., MK-76, BDU-45, BDU-48, BDU-56 and MK-80-series bombs), and live MK-80-series bombs and precision guided munitions (Laser Guided Bombs [LGBs] or Laser Guided Training Round [LGTRs]). Cluster bombs, fuel-air explosives, and incendiary devices are not authorized on FDM. Depleted uranium rounds are not authorized on FDM.

BOMBEX (A-G) exercises can involve a single aircraft, a flight of two, four, or multiple aircraft. The types of aircraft that frequent FDM are FA-18, AV-8B, B-1B, B-2, B-52, F-15, F-16, F-22, and A-10.

FDM is an uncontrolled and un-instrumented, laser certified range with fixed targets, which includes CONEX boxes (metal shipping containers) in various configurations within the live-fire zones, and high fidelity anti aircraft missile, and gun shape targets within the inert only zone. COMNAVMAR is the scheduling authority. All aircraft without aid of an air controller must make a clearance pass prior to engaging targets as instructed in the FDM Range Users Manual (COMNAVMARINST 3502.1).

Missile Exercise (Air-to-Ground) (MISSILEX [A-G])

Fixed-winged aircraft and helicopter crews launch missiles at ground targets and ships in port, day and night, with the goal of destroying or disabling vehicles, infrastructure, and personnel.

Table D-28: Missile Exercise (Air-to-Ground) (MISSILEX [A-G])

Range Activity	Platform	System or Ordnance	No Action Alternative	Alternative 1	Alternative 2	Location
STRIKE WARFARE (STW)						
MISSILEX A-G	FA-18; AV-8B; F-15; F-16; F-22; A-10; MH-60R/S; SH-60B; HH-60H; AH-1	TOW; MAVERICK; HELLFIRE	30 annually	60 annually	70 annually	FDM (R-7201)

SH-60B, HH-60H, & MH-60R/S Helicopters with Hellfire Missiles

AGM-114 - Hellfire uses a laser guidance system.

Basic Phase (Unit Level Training) Scenario

One or two helicopters approach and acquire an assigned target, which is then designated with a laser to guide the Hellfire to the target. The laser designator is either own aircraft, wingman, or another source. The helicopter launches one live missile per exercise from an altitude of about 300 ft while in forward flight or in a hover, against a specially prepared target. The target could be a stationary target, or a remote controlled vehicle whose infrared signature has been augmented with a heat source (charcoal or propane) to better represent a typical threat vehicle. In any case, the targets are not usually expended.

Integrated and Sustainment Phase Training Scenarios

Typically do not differ from the Basic Phase Scenario.

Training Considerations

This exercise is more commonly done in a Warning Area at sea, which can better accommodate the Hellfire's large safety footprint. In the last several years, the Navy has had very few inert Hellfire missiles in its inventory, which has required the expenditure of live Hellfire missiles during training exercises.

<u>F/A-18C/E/F Aircraft with Maverick, SLAM-ER or JSOW</u>

- AGM-65 - Maverick uses infrared guidance.
- AGM-84 - Stand-off Land Attack Missile - Extended Range (SLAM-ER) uses GPS-aided Inertial Navigation System, IR, and datalink guidance.
- AGM-154 - Joint Stand-Off Weapon (JSOW) uses GPS guidance.

Basic Phase (Unit Level Training) Scenario

A flight of two aircraft approach a land target from an altitude between 40,000 ft and 25,000 ft for SLAM-ER or JSOW (high) and 25,000 ft and 5,000 ft for Maverick or JSOW (low), complete the internal targeting process, and launch the weapon at the target beyond 150 nm for SLAM-ER, 60 nm for JSOW (high), 15 nm for JSOW (low), and 12 nm for Maverick. Unit level training is usually highly structured to achieve desired training results. The majority of unit level exercises involve the use of captive carry (inert, no release) training missiles, where the aircraft can perform all detection, tracking, and targeting requirements without actually releasing a missile.

Targets used may include bulls-eyes of concentric rings, real or simulated wheeled vehicles, convoys, trains, aircraft, buildings, petroleum and oil storage areas, personnel silhouettes, and artillery and missile sites. Mobile targets include remotely controlled wheeled vehicles.

Feedback to land based participants can include any combination of real-time and post-mission feedback from a impact scoring system or instrumented range, real-time visual sighting by range observers or participating aircrews, and post-mission telephonic or facsimile debrief. With some A-G missiles, feedback may also include other indications from the target such as the loss or absence of an RF emission following target the attack.

Integrated and Sustainment Phase Training Scenarios

Typically do not differ from the Basic Phase Scenario, except that an E-2 aircraft may participate in the integrated or sustainment phase exercise to assist with targeting procedures and command and control of several sections (four or more) of F/A-18.

Training Considerations

Because of the expense and large safety footprint, the Navy launches very few live missiles per year, land or sea. The typical live annual allocation is one SLAM-ER and one Maverick per squadron. Live Maverick can be launched at sea or at the Fallon Range Training Complex, while live SLAM-ER is typically fired only at sea. The missiles will typically be fired at a decommissioned ship during a SINKEX.

Local Training Considerations

Air-to-ground Missile Exercise trains aircraft crews in the use of air-to-ground missiles. On FDM it is conducted mainly by H-60 Aircraft using Hellfire missiles and occasionally by fixed wing aircraft using Maverick missiles. A basic air-to-ground attack involves one or two H-60 aircraft. Typically, the aircraft will approach the target, acquire the target, and launch the missile. The missile is launched in forward flight or at hover at an altitude of 300 feet Above Ground Level (AGL).

Missile Exercise (Surface-to-Air) (MISSILEX (S-A))

Surface ships engage threat missiles and aircraft with missiles with the goal of disabling or destroying the threat.

There is a training restriction on firing surface-to-air missiles from all surface ships, except aircraft carriers (CVN). Only CVNs fire surface-to-air missiles for training. Other surface-to-air missiles are typically fired for a RDT&E purpose.

Table D-29: Missile Exercise (Surface-to-Air) (MISSILEX [S-A])

Range Activity	Platform	System or Ordnance	No Action Alternative	Alternative 1	Alternative 2	Location
AIR WARFARE						
MISSILEX Ship-to-Air	CVN, LHD, CG, DDG; BQM-74E.	RIM-7 Sea Sparrow RIM-116 RAM RIM-67 SM-II ER	1 (1 missile)	2 (2 missile)	2 (2 missile)	PRI: W-517 SEC: MI Maritime, >12nm from land; ATCAAs

<u>CVN, CG, DDG, FFG, LHA, LHD, LSD, LPD, AOE with Point Defense Missiles</u>

Point defense missiles are designed to defend the ships on which they are installed. These missiles are installed on various surface ships and are not inclusive in every class (the specific ship, by name, must be identified to determine what, if any, point defense missile system is installed):

- NATO Sea Sparrow - may be installed on AOE, LHD, CVN
- Evolved NATO Sea Sparrow, scheduled to replace NATO Sea Sparrow - may be installed on CG, LHA, AOE
- Rolling Airframe Missile - may be installed on CVN, FFG, LHA, LHD, LSD, LPD.
- Standard Missile – installed on CG, DDG

Basic Phase (Unit Level Training) Scenario

The scenario for this exercise is the same as for the main battery gun exercise above, but the simulated threat missile is engaged with the point defense missile system. One live or telemetered-inert-missile is expended against a target towed by a commercial air services Lear jet after two or three tracking runs. The exercise lasts about two hours.

The BQM-74 target, sometimes augmented with a TDU, is used an alternate target for this exercise. The BQM target is a subscale, subsonic, remote controlled ground or air launched target. A parachute deploys at the end of target flight to enable recovery at sea.

Training Considerations

The CVN is currently the only ship to have a periodic training requirement with an actual live missile shot. Other surface ships routinely conduct the "detect to engage exercise," without a live missile firing, using a missile training round simulator. The training requirement for other ships to fire live or inert telemetry missiles on a periodic or test basis is continually subject to review or exemption.

CG, DDG with Standard Missile (SM-2)

CGs and DDGs use the Standard Missile (SM-2) to defend the force against threat missiles and aircraft. These ships are tactically stationed to defend the aircraft carrier, amphibious ships, or logistic ships of the force, as well as themselves, from the air threat.

Basic Phase (Unit Level Training) Scenario

One live or telemetered-inert-missile is fired against a missile target or jet/towed target after conducting a tracking run. The exercise lasts about two hours.

The BQM-74 target, sometimes augmented with a TDU, is used an alternate target for this exercise. The BQM target is a subscale, subsonic, remote controlled ground or air launched target. A parachute deploys at the end of target flight to enable recovery at sea.

Training Considerations

The "detect to engage exercise" is used to conduct this training where there is no longer a training requirement for these ships to fire live or inert missiles.

Naval Surface Fire Support (NSFS) Exercise (FIREX)

Surface ships use main battery guns to support forces ashore in their battle against threat forces.

NSFS normally consists of the bombardment of a target within an impact area, by one or more ships. The ship is often supported by Navy, Marine, or NSW spotters ashore, or by spotters embarked in fixed-wing aircraft or helicopters in the air, to call for the fire support from the ship, and to adjust the fall of shot onto the target.

The locations and opportunities for live-fire from a ship at sea to targets ashore are very limited, and often the training range area is not adequate to establish and maintain surface fire support proficiency.

Table D-30: Naval Surface Fire Support (NSFS) Exercise (FIREX)

Range Activity	Platform	System or Ordnance	No Action Alternative	Alternative 1	Alternative 2	Location
AMPHIBIOUS WARFARE (AMW)						
FIREX (Land)	CG, DDG	5" Guns and (HE) shells	4 (400 rounds)	8 (800 rounds)	10 (1,000 rounds)	FDM (R-7201)

CG and DDG with 5-inch Guns

FIREX (Land Target) (FIREX (Land))

This exercise uses a land area where live and inert ordnance is authorized to impact and is often supported by target shapes such as tanks, truck, trains, or aircraft on the ground. These targets add to the realism for both the spotters and the ships involved in the exercise.

Basic Phase (Unit Level Training) Scenario

The ship positions itself about four to six nm from the target area to receive information concerning the target and the type and exact location of the target from the assigned spotter. One or more rounds are fired at the target. The fall of the round is observed by the spotter, who then tells the ship if the target was hit or if the ship needs to adjust where the next round should fall. More shots are fired, and once the rounds are falling on the target, then the spotter will request a larger number of rounds to be fired to effectively destroy the target. Typically five rounds are fired in rapid succession (about one round every five to seven seconds). Ten or more minutes will pass, and then similar missions will be conducted until the allocated number of rounds for the exercise has been expended.

About 70 rounds of 5-inch inert or high explosive ordnance (typically 53% live and 47% inert), in addition to about 5 rounds of illumination are expended by the CG or DDG during a typical exercise. Portions of the exercise are conducted during both the day and the night to achieve full qualification. A ship will normally conduct three FIREXs at different levels of complexity over several months to become fully qualified.

A Shore Fire Control Party (SFCP) may consist of about 10 personnel who supply target information to the ship. From positions on the ground, the Navy, Marine, or NSW personnel who make up the SFCP provide the target coordinates at which the ship's crew directs its fire. As the rounds fall, the SFCP records where the rounds falls and provide adjustments to the fall of shot, as necessary, to ensure the target is "destroyed."

Integrated and Sustainment Phase Training Scenarios

Typically does not differ significantly from the Basic Phase Scenario with respect to the NSFS procedures and ordnance used.

If NSFS training is conducted as part of an ESGEX, in could be part of several independent or coordinated missions being conducted simultaneously, including CAS, Marine Corps artillery fires, and troop movements, that are being coordinated by the Expeditionary Strike Group Commander embarked in the LHA. In a training environment, it is expected that NSFS is only combined with Marine Corps artillery fires as a live or inert ordnance exercise in the same area.

Local Training Considerations

FIREX (Land) on FDM consists of the shore bombardment of an Impact Area by Navy guns as part of the training of both the gunners and Shore Fire Control Parties (SFCP). A SFCP consists of spotters who act as the eyes of a Navy ship when gunners cannot see the intended target. From positions on the ground or air, spotters provide the target coordinates at which the ship's crew directs its fire. The spotter provides adjustments to the fall of shot, as necessary, until the target is destroyed. On FDM, spotting may be conducted from the special use 'no fire' zone or provided from a helicopter platform. No one may land on the island without the express permission of COMNAVMAR (COMNAVMARINST 3502.1).

Marksmanship

Navy personnel use small arms and small unit tactics to defend unit positions or attack simulated enemy positions with the goal of defending the unit position or clearing an area of a threat.

Marksmanship exercises are used to train personnel, beyond basic introductory skills, in the use of all small arms weapons for the purpose of ship self defense and security as well as NSW personnel in many of their training tasks.

Special Warfare, NECC, Shipboard and Other personnel with Small Arms

Marksmanship exercises may include but are not limited to 9 mm pistols, 12-gauge shotguns, .50 cal, 7.62 mm, 5.56 mm rifles and machine guns, and 40 mm grenades.

Basic Phase (Unit Level Training) Scenario

A squad, or other size unit, of personnel uses small unit tactics and small arms to approach a simulated hostile target area manned by an opposing force. The opposing force in this case may be popup targets and other targets designed to improve the marksmanship of the individual squad members.

Training Considerations

Basic marksmanship operations are strictly controlled and regulated by specific individual weapon qualification standards and typically occur on specific small arms ranges. While marksmanship exercises can occur on designated small arms ranges ashore, they are also scheduled on live fire or maneuver ranges ashore, MOUT areas ashore, or aboard surface ships at sea firing into the sea.

Local Training Considerations

Marksmanship exercises are used to train personnel in the use of all small arms weapons for the purpose of ship self defense and security. Basic marksmanship operations are strictly controlled and regulated by specific individual weapon qualification standards. Small arms include but are not limited to 9mm pistol, 12-gauge shotgun, and 7.62mm rifles.

Special Warfare Mission Area Training

Mission area training will typically be unique training for a particular unit's mission that can be completed at specific range areas that best support the required training.

Naval Special Warfare and EOD units most commonly have training requirements that fall into this category. This training usually requires a training range or training range support, but may have little or no environmental or community impact.

Table D-31: Special Warfare Mission Area Training

Range Activity	Platform	System or Ordnance	No Action Alternative	Alternative 1	Alternative 2	Location
SPECIAL WARFARE						
HYDROGRAPHIC SURVEYS	SEAL Platoon/Squad; EOD Platoon/Squad; USMC Platoon/Squad; Small Craft; RHIB; CRRC; H-60	SCUBA	3	6	6	PRI: FDM; Tinian; Tipalao Cove SEC: Haputo Beach; Gab Gab Beach; Dadi Beach

Mission Area Training at a typical range complex may include the following operations:

- Hydrographic Reconnaissance. A survey of underwater terrain conditions near shore and a report of findings to provide precise analysis for amphibious landings. Personnel perform methodical reconnoitering of beaches and surf conditions during the day and night to find and clear underwater obstacles and determine the feasibility of landing an amphibious force on a particular beach.
- Closed Circuit Breathing Diving. Swimming and diving in underwater ocean and bay areas with the Lambert Air Rebreather (LAR) V. The LAR V is a 100% oxygen rebreather system that makes use of a small oxygen bottle and a “scrubber” canister that filters the CO2 from your exhaled air and allows you to re-breathe 100% oxygen.
- Open Circuit Breathing Diving. Swimming and diving underwater ocean and bay areas using the typical Self-Contained Underwater Breathing Apparatus (SCUBA) equipment, including compressed air and MK-16 mixed gas SCUBA equipment.
- Surf Observations. Recording information about ocean surf conditions using standard documentation methods for amphibious operations.
- Inflatable Small Boat Surf Passage. Various methods are learned for bringing inflatable small boats through the surf from sea to shore or shore to sea.
- Rock Portage. Various methods are learned to move small boats and equipment through rocky areas that would typically be found at the sea/shore beach interface.
- Land Patrolling. Various methods for patrolling and moving through various land terrain areas are learned by squads of about seven to 15 personnel.

- NSW Scout Training. Special tactical techniques are learned for observing threat areas and areas that may later be used by friendly forces to gain the most information from all available sources in the field.
- Advanced Close Quarters Defense Training. Hand-to-hand combat techniques within special training facilities to teach special tactical techniques with and without weapons.
- NSW Photo Image Capture. Tactical patrolling techniques to move in and out of a threat area without leaving any trace that anyone was there, while capturing detailed photography of the assigned threat.

Local Training Considerations

Hydrographic Reconnaissance is conducted to survey underwater terrain conditions and report findings to provide precise analysis typically in support of amphibious landings and precise ship and small craft movement through cleared routes (Q-Routes). Exercises involve the methodical reconnoitering of beach and surf conditions during the day and night to find and clear underwater obstacles and to determine the feasibility of landing an amphibious force on a particular beach. Explosive Ordnance Disposal (EOD) units periodically survey FDM to determine the condition of coral around the island and to detect the presence of Unexploded Ordnance (UXO).

Combat Search and Rescue (CSAR)

Fixed-winged aircraft, helicopters and submarines use tactical procedures to rescue military personnel within a hostile area of operation.

Table D-32: Combat Search and Rescue (CSAR)

Range Activity	Platform	System or Ordnance	No Action Alternative	Alternative 1	Alternative 2	Location
STRIKE WARFARE (STW)						
COMBAT SEARCH AND RESCUE (CSAR)	SH-60; MH-60; HH-60; MH-53; CH-53; C-17; C-130; V-22	NIGHT VISION	30 sorties	60 sorties	75 sorties	PRI: Tinian North Field: Guam Northwest Field SEC: Orote Point Airfield; Rota Airport

<u>HH-60H, SH-60F, MH-60S with Machine Guns</u>

Basic Phase (Unit Level Training) Scenario

Helicopters fly below 3,000 ft at the best altitudes and speeds between 50 kts. and 100 kts. to approach the area where the suspected personnel to be rescued are located. Machine guns (7.62 mm or 5.56 mm) will be mounted in the side door, but blank ammunition is normally used in this exercise. Chaff and flares may be expended if a surface-to-air or air-to-air threat or opposing force is available and an additional level of complexity is desired for the scenario. NSW personnel may be embarked during this exercise to act as the rescue party. This NSW squad would debark from the helicopter, “rescue” the personnel to be recovered, and return to the helicopter to be removed from the area. This basic exercise would last about one and a half hours.

Integrated and Sustainment Phase Training Scenarios

The basic procedures completed by the helicopter and embarked personnel are typically the same. The added complexity is the required coordination between rescue units and support from additional participants. See the E-2C and F/A-18C/E/F scenario below.

Training Considerations

See the E-2C and F/A-18C/E/F scenario below.

E-2C and F/A-18C/E/F with Cannon or Bombs

Basic Phase (Unit Level Training) Scenario

CSAR is typically conducted by these units in the integrated or sustainment phase training scenario.

Integrated and Sustainment Phase Training Scenarios

The E-2 will serve as a command and control element for the evolution while flying at an altitude of about 20,000 ft at a cruising speed of about 260 kts. Remaining within an assigned station, the E-2 will maintain communications and a tactical picture of the area containing the personnel to be rescued and other forces involved in the evolution. Two F/A-18 will serve as a Rescue Combat Air Patrol or Rescue Escort. In this role they will approach the rescue area at altitudes below 3,000 ft, down to about 300 ft where they can observe the area and provide protection as required with cannon (GUNEX (A-G)) or bombs (BOMBEX (A-G)) for both the personnel to be rescued as well as helicopters (HH-60H, SH-60F, MH-60S) and ground forces (NSW or Marine Corps) conducting the rescue. The principal focus of this exercise is the integration and coordination of actions between the various platforms involved. A CSAR exercise will last between two and three hours.

Training Considerations

This exercise will be supported by an opposition force and in conjunction with other exercises.

SSN, SSGN, SSBN

Basic Phase (Unit Level Training) Scenario

The submarine will proceed to a specified location at sea in a hostile area near land where the rescue is to be made, come to a depth of about 60 ft and visually search for the person to be rescued. Once the person is located, the submarine will surface just long enough to embark the persons to be rescued, and then leave the area.

Integrated and Sustainment Phase Training Scenarios

Not typically conducted in these phases.

Training Considerations

May be combined with insertion and extraction training.

Local Training Considerations

CSAR operations train rescue forces personnel the tasks needed to be performed to affect the recovery of distressed personnel during war or military operations other than war. These operations could include aircraft, surface ships, submarines, ground forces (Marine Corps and NSW), and their associated personnel in the execution of training events.

In FY03 North Field supported NVG familiarization training for CSAR operators from the USS KITTY HAWK.

Force Protection

Force protection operations increase the physical security of military personnel in the region to reduce their vulnerability to attacks. Force protection training includes moving forces and building barriers, detection, and assessment of threats, delay, or denial of access of the adversary to their target, appropriate response to threats and attack, and mitigation of effects of attack. Force protection includes employment of offensive as well as defensive measures.

Table D-33: Force Protection

Range Activity	Platform	System or Ordnance	No Action Alternative	Alternative 1	Alternative 2	Location
FORCE PROTECTION / ANTI-TERRORISM						
ANTI-TERRORISM	Navy Base Security USAF Security Squadron USMC FAST Platoon Trucks; HMMWV; MH-60	5.56 mm blanks/Simulations	80 events, 1 day/event	80 events, 1 day/event	80 events, 1 day/event	PRI: Tarague Beach Shoot House and CATM Range; Polaris Pt.; Northwest Field. SEC: Kilo Wharf; Finegayan Comm. Annex; Navy Munitions Site; AAFB Munitions Site

Local Training Considerations

Base Naval Security Forces and MSS-7 frequently conduct force protection training throughout the Waterfront Annex, but all forces will participate in force protection training to some degree in multiple locations throughout the MIRC.

Anti-Terrorism

Anti-Terrorism (AT) operations concentrate on the deterrence of terrorism through active and passive measures, including the collection and dissemination of timely threat information, conducting information awareness programs, coordinated security plans, and personal training. The goal is to develop protective plans and procedures based upon likely threats and strike with a reasonable balance between physical protection, mission requirements, critical assets and facilities, and available resources to include manpower.

Anti-Terrorism Operations may involve units of Marines dedicated to defending both U.S. Navy and Marine Corps assets from terrorist attack. The units are designated as the Fleet Anti-Terrorism Security Team, or FAST. FAST Company Marines augment, assist and train installation security when a threat condition is elevated beyond the ability of resident and auxiliary security forces. They are not designed to provide a permanent security force for the installation. They also ensure nuclear material on submarines is not compromised when vessels are docked. FAST Companies deploy only upon approval of the Chief of Naval Operations.

Table D-34: Anti-Terrorism

Range Activity	Platform	System or Ordnance	No Action Alternative	Alternative 1	Alternative 2	Location
FORCE PROTECTION / ANTI-TERRORISM						
FORCE PROTECTION	USAF Squadron/ Platoon NECC SEABEE Company/ Platoon USAR Engineer Company/ Platoon Tents; Trucks; HMMWV; Generators	5.56 mm blanks/Simulations	60 events, 1-2 days per event	75 events, 1-2 days per event	75 events, 1-2 days per event	PRI: Guam, Northwest Field; Northern Land Navigation Area; Barrigada Annex SEC: Orote Pt. Airfield; Polaris Pt. Field; Tinian North Field.

Local Training Considerations

The USMC Security Force FAST Platoon stationed in Yokosuka, Japan conducts Anti Terrorism training with Base Naval Security, NSWU-1, and EODMU-5 support and in multiple locations within the MIRC in Guam.

Field Training Exercise (FTX)

FTX is an exercise where the battalion and its combat and combat service support units deploy to field locations to conduct tactical operations under simulated combat conditions.

Table D-35: Field Training Exercise (FTX)

Range Activity	Platform	System or Ordnance	No Action Alternative	Alternative 1	Alternative 2	Location
SPECIAL/EXPEDITIONARY WARFARE						
FIELD TRAINING EXERCISE (FTX)	ARMY Company/ Platoon NECC SEABEE Company/ Platoon	Tents; Trucks; HMMWV; Generators	100 events, 2-3 days per event	100 events, 2-3 days per event	100 events, 2-3 days per event	PRI: Guam, Northwest Field; Northern Land Navigation Area SEC: Orote Pt. Airfield; Polaris Pt. Field; Tinian North Field.

Local Training Considerations

A company or smaller-sized element of the Army Reserve, Guam Army National Guard, or Guam Air National Guard will typically accomplish FTX within the MIRC, due to the constrained environment for land forces. The headquarters and staff elements may simultaneously participate in a CPX mode.

Surveillance and Reconnaissance (S&R)

Surveillance and reconnaissance is conducted to evaluate the battlefield, enemy forces, and gather intelligence. For training of assault forces, “red cell” or “OPFOR” units may be positioned ahead of the assault force and permitted a period of time to conduct S&R and prepare defenses to the assaulting force.

Table D-36: Surveillance and Reconnaissance (S&R)

Range Activity	Platform	System or Ordnance	No Action Alternative	Alternative 1	Alternative 2	Location
SPECIAL/EXPEDITIONARY WARFARE						
Intelligence, Surveillance, Reconnaissance (ISR)	SEAL Platoon/Squad; ARMY Platoon/Squad; USMC Platoon/Squad; USAF Platoon/Squad	Night Vision; Combat Camera; 5.56 mm blanks/Simunition	12 Events; 8 – 24 hours	16 Events; 8 – 24 hours	16 Events; 8 – 24 hours	PRI: Guam; Northwest Field; Barrigada Housing; Finegayan Comm. Annex; Orote Pt. Airfield. SEC: Tinian, Rota, Saipan

Local Training Considerations

None documented.

USAF Airlift—Air Expeditionary—Force Protection

- Provide airlift support to combat forces.
- Provide air expeditionary operations support to forward deployed forces
- Provide Force Protection

Table D-37: USAF Airlift--Air Expeditionary—Force Protection

Range Activity	Platform	System or Ordnance	No Action Alternative	Alternative 1	Alternative 2	Location
SPECIAL/EXPEDITIONARY WARFARE						
AIRFIELD EXPEDITIONARY	USAF RED HORSE Squadron. NECC SEABEE Company. USMC Combat Engineer Company USAR Engineer Dozer, Truck, Crane, Forklift, Earth Mover, HMMWV. C-130; H-53.	Expeditionary Airfield Repair and Operation	1	12	12	PRI: Northwest Field SEC: Orote Pt. Airfield; Tinian North Airfield

Local Training Considerations

Northwest Field is used in support of expeditionary training and is available as an alternate landing and lay down site for short field capable aircraft.

Miscellaneous Range Events

Sinking Exercise (SINKEX)

A SINKEX is typically conducted by aircraft, surface ships, and submarines in order to take advantage of a full size ship target and an opportunity to fire live weapons.

The target is typically a decommissioned combatant or merchant ship that has been made environmentally safe for sinking. It is placed in a specific location so that when it sinks it will serve another purpose, such as a reef, or be in deep water where it will not be a navigation hazard to other shipping.

Ship, aircraft, and submarine crews typically are scheduled to attack the target with coordinated tactics and deliver live ordnance to sink the target. Inert ordnance is often used during the first stages of the event so that the target may be available for a longer time. The duration of a SINKEX is unpredictable because it ends when the target sinks, but the goal is to give all forces involved in the exercise an opportunity to deliver their live ordnance. Sometimes the target will begin to sink immediately after the first weapon impact and sometimes only after multiple impacts by a variety of weapons. Typically, the exercise lasts for 4 to 8 hours and possibly over 1 to 2 days, especially if inert ordnance, such as 5-inch gun projectiles or MK-76 dummy bombs, is used during the first hours.

A SINKEX is conducted under the auspices of a permit from the U.S. Environmental Protection Agency (EPA).

Table D-38: Sinking Exercise (SINKEX)

Range Activity	Platform	System or Ordnance	No Action Alternative	Alternative 1	Alternative 2	Location
SURFACE WARFARE (SUW)						
SINKEX	Ship hulk or barge	HARM [2] SLAM-ER [4] HARPOON [5] 5" Rounds [400] HELLFIRE [2] MAVERICK [8] GBU-12 [10] GBU-10 [4] MK-48 [1] Underwater Demolitions [2 -100lb]	1	2	2	PRI: W-517 SEC: MI Maritime, >50 nm from land; ATCAAs

The participants and assets could include:

- One full-size target ship hulk
- One to five CG, DDG, or FFG firing ships
- One to 10 F/A-18, or MPA firing aircraft
- One or two HH-60H, MH-60R/S, or SH-60B Helicopters
- One E-2 aircraft for Command and Control

- One firing submarine
- One to three range clearance aircraft.

Some or all of the following weapons could be employed:

- Two to four Harpoon surface-to-surface or air-to-surface missiles
- Two to eight air-to-surface Maverick missiles
- Two to 16 MK-82 / MK-84 General Purpose Bombs
- Two to four Hellfire air-to-surface missiles
- One or two SLAM-ER air-to-surface missiles
- Fifty to 500 rounds 5-inch and 76 mm gun
- One MK-48 heavyweight submarine-launched torpedo
- Two to Ten Thousand rounds .50 cal and 7.62 mm.

Major Range Events

Table D-39: Annual Major Exercise Activities in the Mariana Islands Range Complex

MIRC EIS/OEIS		Major Exercises							
Exercise		**Joint Expeditionary Exercise (CSG + ESG)**	**Joint Multi-strike Group Exercise (3 CSG + USAF)**	**Fleet Strike Group Exercise (CSG)**	**Integrated ASW Exercise (CSG)**	**Ship Squadron ASW Exercise (CRU DES)**	**MAGTF Exercise (STOM/ NEO)**	**SPMAGTF Exercise (HADR/ NEO)**	**Urban Warfare Exercise**
Exercise Sponsor		US PACOM	US PACOM	C7F	C7F	C7F	III MEF	III MEF; MEU/UDP	III MEF; MEU/ UDP
Alternative: No Action		1 of the above		0	0	0	1	0	2
Alternative 1		1	1	0	0	0	4	2	5
Alternative 2		1	1	1	1	1	4	2	5
Primary Training Site		Tinian	MI Maritime >12 NM	MI Maritime >12 NM	MI Maritime >3 NM	MI Maritime >3 NM	Tinian	Guam	Guam
Secondary Training Sites		Nearshore to OTH: Guam: Rota; Saipan; FDM	FDM	FDM	FDM	N/A	Nearshore to OTH: Guam: Rota; Saipan; FDM	Tinian, Rota, Saipan	Tinian, Rota, Saipan
Exercise Footprint	**Activity Days per Exercise**	10	10	7	5	5	10	10	7-21
NAVY SHIPS	**CVN**	1	3	1	1	0	0	0	0
	CG	1	3	1	1	1	0	0	0
	FFG	2	3	1	1	1	1	0	0
	DDG	5	12	3	3	3	2	0	0
	LHD/ LHA	1	0	1	0	0	1	1	1
	LSD	2	0	0	0	0	2	1	1
	LPD	1	0	0	0	0	1	1	1
	TAOE	1	3	1	0	0	0	0	N/A
	SSN	1	5	1	1	1	0	0	N/A
	SSGN	1	0	0	0	0	1	0	0
	TR	N/A	N/A	0	0	0	N/A	N/A	N/A
Partner National Ships	**CG**	1	0	0	0	0	0	0	N/A
	DDG	2	0	0	0	0	0	0	N/A
	SS	1	1	0	0	0	0	0	N/A
FIXED WING	**F/A-18**	4 Squadrons	12 Squadrons	4 Squadrons	4 Squadrons	N/A	N/A	N/A	N/A
	EA-6B	1 Squadron	3 Squadrons	1 Squadron	1 Squadron	N/A	N/A	N/A	N/A
	E-2	1 Squadron	3 Squadrons	1 Squadron	1 Squadron	N/A	N/A	N/A	N/A
	MPA (P-3)	3	5	3	3	3	N/A	N/A	N/A
	AV-8B	1 Squadron	N/A	1 Squadron	N/A	N/A	N/A	N/A	N/A
	C-130	2	N/A	N/A	N/A	N/A	1	1	1
	USAF Bomber	N/A	1 Squadron	N/A	N/A	N/A	N/A	N/A	N/A
	F-15/16/22	N/A	1 Squadron	1 Squadron	N/A	N/A	N/A	N/A	N/A
	A-10	4	N/A	N/A	N/A	N/A	N/A	N/A	N/A

Table D-39: Annual Major Exercise Activities in the Mariana Islands Range Complex (Continued)

MIRC EIS/OEIS		Major Exercises							
Exercise		Joint Expeditionary Exercise (CSG + ESG)	Joint Multi-strike Group Exercise (3 CSG + USAF)	Fleet Strike Group Exercise (CSG)	Integrated ASW Exercise (CSG)	Ship Squadron ASW Exercise (CRU DES)	MAGTF Exercise (STOM/ NEO)	SPMAGTF Exercise (HADR/ NEO)	Urban Warfare Exercise
Exercise Sponsor		US PACOM	US PACOM	C7F	C7F	C7F	III MEF	III MEF; MEU/UDP	III MEF; MEU/ UDP
	E-3	1	1	1	N/A	N/A	N/A	N/A	N/A
	KC-10/135/130	1	2	1	N/A	N/A	N/A	N/A	N/A
ROTARY	MH-60R/S	4	12	4	4	4	2	N/A	N/A
	SH-60H	4	12	4	4	4	N/A	N/A	N/A
	HH-60H	4	12	4	4	N/A	N/A	N/A	N/A
	SH-60F	3	9	3	3	N/A	N/A	N/A	N/A
	CH-53	4	N/A	4	N/A	N/A	4	4	4
	CH-46	12	N/A	12	N/A	N/A	12	12	12
	AH-1	4	N/A	4	N/A	N/A	4	4	4
	UH-1	2	N/A	2	N/A	N/A	2	2	2
	MV-22 FY10 (replace CH-46)	10	N/A	10	N/A	N/A	10	10	10
UAS	Ship Based	2	3	1	1	0	1	0	0
	Ground Based	2	1	0	0	0	2	1	1
Landing Craft	LCAC	3-5	N/A	N/A	N/A	N/A	3-5	3	N/A
	LCU	1-2	N/A	N/A	N/A	N/A	1-2	1	N/A
	CRRC	18	N/A	N/A	N/A	N/A	18	18	0
GCE	AAV	14	N/A	N/A	N/A	N/A	14	3	3
	LAV	13	N/A	N/A	N/A	N/A	5	5	5
	HMMWV	78	N/A	N/A	N/A	N/A	78	16	16
	Ground Personnel	1200	N/A	N/A	N/A	N/A	1200	250	250
LCE	Trucks	36	N/A	N/A	N/A	N/A	36	8	8
	Dozer	2	N/A	N/A	N/A	N/A	2	1	1
	Forklift	6	N/A	N/A	N/A	N/A	6	2	2
	ROWPU	2	N/A	N/A	N/A	N/A	2	1	1
	RHIB	2	N/A	N/A	N/A	N/A	2	2	2
	Ground Personnel	300	N/A	N/A	N/A	N/A	300	60	60

Joint Expeditionary Exercise

The Joint Expeditionary Exercise brings different branches of the U.S. military together in a joint environment that includes planning and execution efforts as well as military operations at sea, in the air, and ashore. The purpose of the exercise is to train a U.S. Joint Task Force staff in crisis action planning for execution of contingency operations. It provides U.S. forces an opportunity to practice training together in a joint environment as well as a combined environment with partner nation forces, where more than 8,000 personnel may participate.

The participants and assets could include:

- Fleet and Battle Group Staffs
- Aircraft carrier
- Cruisers
- Guided missile destroyers
- Amphibious command and assault ships
- Submarines
- Mobile logistic ships
- Naval and Air Force aircraft
- Marine Expeditionary Units (MEU)
- Army Infantry Units.

Military operations would be conducted at sea and in the air near, and ashore on Tinian, FDM, Guam, and Saipan.

Training in Urban Environment Exercise (TRUEX)

TRUEX is a MEU integration level exercise conducted over a period of weeks. MEU personnel enhance the skills needed for military operations in an urban environment. Events typically take place on Guam and utilize Finegayan Housing, Andersen South, Barrigada Housing, and Northwest Field. TRUEX has been conducted in Saipan as part of the Joint Expeditionary Exercise. TRUEX on Tinian and Rota is possible however due to distance and lack of infrastructure support they are secondary sites..

Joint Multi-Strike Group Exercise

The Joint Multi-Strike Group Exercise demonstrates the Navy's ability to operate a large Naval force of up to three Carrier Strike Groups in coordination with other Services. In addition to this Joint warfare demonstration, it also fulfills the Navy's requirement to maintain, train, and equip combat-ready naval forces capable of winning wars, deterring aggression, and maintaining freedom of the seas. The Joint Multi-Strike Group conducts training involving Navy assets engaging in a schedule of events (SOE) battle scenario, with United States (U.S.) forces pitted against a notional opposition force (OPFOR). Participants use and build upon previously gained training skill sets to maintain and improve the proficiency needed for a mission-capable, deployment-ready unit. The exercise includes the at sea activities described below:

Command and Control (C2): A command organization exercises operational control of the assets involved in the exercise. This control includes monitoring for safety and compliance with protective measures.

Air Warfare (AW): AW includes missile exercises which involve firing live missiles at air targets. Ships and aircraft fire missiles against air targets. AW also includes non-firing events such as Defensive Counter Air (DCA). DCA exercises ship and aircrew capabilities at detecting and reacting to incoming airborne threats.

Anti-Surface Warfare (ASUW): Naval forces control sea lanes by countering hostile surface combatant ships. Two methods will be utilized for neutralizing opposition force ships: Maritime Interdiction (MI) and Air Interdiction of Maritime Targets (AIMT). MI is the use of Navy ships to counter the surface threat, while AIMT involves the use of U.S. aircraft. Two SINKEX may be conducted. These are live-fire events in which ship hulks are fired upon and sunk. The firing platforms can include aircraft, surface ships, and submarines.

Anti-Submarine Warfare (ASW): During ASW activities, air, surface and submarine units would be used to locate and track opposition force submarines. Methods used to locate and track submarines include acoustic (active and passive sonar), visual, and electronic. ASW will include the use of Surveillance Towed Array Sensor System Low Frequency Active (SURTASS LFA).

Fleet Strike Group Exercise

The Fleet Strike Group Exercise is a one week event focused on sustainment training for the forward deployed Carrier Strike Group and may integrate joint operations with the U.S. Air Force and U.S. Marine Corps in the Western Pacific. The exercise focuses on integrated joint training among U.S. military forces in the maritime environment with an ASW threat; enabling real-world proficiency in detecting, locating, tracking and engaging units at sea, in the air, and on land, in response to a range of mission areas.

Integrated ASW Exercise

This is a five day Anti-Submarine Warfare (ASW) exercise conducted by the forward deployed Navy Strike Groups to sustain and assess their ASW proficiency while located in the Seventh Fleet area of operations; the exercise is designed to assess the Strike Groups' ability to conduct ASW in the most realistic environment, against the level of threat expected, in order to effect changes to both training and capabilities (e.g., equipment, tactics, and changes to size and composition) of U.S. Navy Strike Groups. The Strike Group receives significant sustainment training value in ASW and other warfare areas, as training is inherent in all at-sea exercises.

The Strike Group must demonstrate strike warfare capabilities of the strike group while establishing and maintaining control over any threats posed by submarines. CSGs must demonstrate the ability to enter a theater, transit through littoral or simulated littoral waterspace that restricts the maneuverability of the strike group, establish an operating area, and conduct air strikes against land and sea based targets. The ESG must demonstrate the ability to enter a theater, transit through littoral or simulated littoral waterspace that restricts the maneuverability of the strike group, establish an operating area, and conduct amphibious warfare operations in a shallow littoral or simulated littoral environment.

Ship Squadron ASW Exercise

The Ship Squadron ASW Exercise overall objective is to sustain and assess surface ship ASW readiness and effectiveness. The exercise typically involves multiple ships, submarines, and aircraft in several coordinated events over a period of a week or less. Maximizing opportunities to collect high-quality data to support quantitative analysis and assessment of operations is an additional goal of this training.

Marine Air Ground Task Force (Amphibious) Exercise

Ship to Objective Maneuver/Noncombatant Evacuation Operation (STOM/NEO)

This exercise may last up to ten days and conducts over the horizon, ship to objective maneuver of the elements of the ESG and the Amphibious MAGTF. The exercise utilizes all elements of the MAGTF to secure the battlespace (air, land, and sea), maneuver to and seize the objective, conduct self-sustaining operations ashore with continual logistic support of the ESG. Tinian is the primary MIRC training area for this exercise, however elements of the exercise may be rehearsed nearshore and on Guam.

Table D-40: Ship to Objective Maneuver/Noncombatant Evacuation Operation (STOM/NEO)

Range Activity	Platform	System or Ordnance	No Action Alternative	Alternative 1	Alternative 2	Location
AMPHIBIOUS WARFARE (AMW)						
Amphibious Assault Marine Air Ground Task Force (MAGTF)	1 LHA or LHD, 1 LPD, 1 LSD, 1 CG or DDG, and 2 FFG.	4-14 AAV/EFV or LAV/LAR; 3-5 LCAC; 1-2 LCU; 4 H-53; 12 H-46 or 10 MV-22; 2 UH-1; 4 AH-1; 4 AV-8	1 event (assault, offload, backload)	5 events (assault, offload, backload)	5 events (assault, offload, backload)	PRI: Tinian Military Leased Area; Unai Chulu (beach) and Tinian Harbor; North Field. SEC: Apra Harbor; Reserve Craft Beach; Polaris Point Beach (MWR) and Polaris Point Field; Orote Point Airfield; Sumay Cove and MWR Ramp

Special Purpose Marine Air Ground Task Force Exercise

(Humanitarian Assistance/Disaster Relief/ Noncombatant Evacuation Operations [NEO])

Marine Corps units bring relief to or evacuate noncombatants from an area where the lives of the people being are endangered by war, civil unrest, or natural disaster.

Training Scenario

Special Purpose MAGTF, typically operating in conjunction with Navy ships and aircraft conduct humanitarian and disaster relief, or evacuation of noncombatants from foreign countries to safe havens. or back to the United States when their lives are endangered by war, civil unrest, or natural disaster. Normally, there is no opposition from the host country, however Marine Corps Special Purpose MAGTF or MEU(SOC)s normally train for evacuation under a circumstance that requires the use of force in a hostile environment. Much like a raid, a NEO involves the rapid introduction of forces, the evacuation of non-combatants, and a planned withdrawal. A MEU(SOC), H-53, H-46, or H-60 helicopters, LCACs or other landing craft could be expected to participate in this operation during day or night. Guam is the primary training are for this exercise.

Table D-41: Special Purpose Marine Air Ground Task Force Exercise

Range Activity	Platform	System or Ordnance	No Action Alternative	Alternative 1	Alternative 2	Location
SPECIAL/EXPEDITIONARY WARFARE						
Humanitarian Assistance/ Disaster Relief Operation (HADR)	Amphibious Shipping (1-LHD; 1-LPD; 1-LSD) USMC Special Purpose MAGTF	HMMWV; Trucks; Landing Craft (LCAC/ LCU); AAV/ LAV; H-46 or MV-22	1 event, 3-5 days	2	2	PRI: Apra Harbor; Reserve Craft Beach; Polaris Point Beach (MWR) and Polaris Point Field; Orote Point Airfield; Northwest Field; Sumay Cove and MWR Marina Ramp SEC: Tinian Military Leased Area; Unai Chulu (beach) and Tinian Harbor; North Field.
Non-Combatant Evacuation Operation (NEO)	Amphibious Shipping (1-LHD; 1-LPD; 1-LSD) USMC Special Purpose MAGTF	HMMWV; Trucks; Landing Craft (LCAC/ LCU); AAV/ LAV; H-46 or MV-22	1 event, 3-5 days	2	2	PRI: Apra Harbor; Reserve Craft Beach; Polaris Point Beach (MWR) and Polaris Point Field; Orote Point Airfield; Northwest Field; Sumay Cove and MWR Marina Ramp SEC: Tinian Military Leased Area; Unai Chulu (beach) and Tinian Harbor; North Field.

Ordnance use by training area

Table D-42: Summary of Ordnance Use by Training Area in the MIRC Study Area[1]

Training Area and Ordnance Type	Number of Rounds Per Year		
	No Action	Alternative 1	Alternative 2
FDM (R-7201)			
Bombs (HE) ≤ 500 lbs	400	500	600
Bombs (HE) 750 / 1000 / 2000 lbs	1,600	1,650	1,700
Inert Bomb Training Rounds ≤ 2000 lbs	1,800	2,800	3,000
Missiles [Maverick; Hellfire; TOW]	30	60	70
Cannon Shells (20 or 25 mm)	16,500	20,000	22,000
Cannon Shells (30 mm)	0	1,500	1,500
AC-130 Cannon Shells (40mm or 105mm)	100	200	200
5" Gun Shells	400	800	1,000
Small Arms [5.56mm; 7.62mm; .50 cal; 40mm]	2,000	3,000	3,000
PRI: Guam Maritime > 3 nm from land SEC: W-517			
MK-48 EXTORP	20	40	48
MK-46 or MK-50 REXTORP	0	7	14
MK-84 SUS (Signal Under Surface Device, Electro-Acoustic)	20	40	48

Table D-42: Summary of Ordnance Use by Training Area in the MIRC Study Area[1] (cont'd)

Training Area and Ordnance Type	Number of Rounds Per Year		
	No Action	Alternative 1	Alternative 2
PRI: W-517 **SEC: Marianas Maritime > 12 nm; ATCAAs**			
Air Deployed Mines [MK-62; MK-56]	320	480	480
Inert Bomb Training Rounds [MK-82 I; BDU-45; MK-76]	48	72	90
5" Gun Shells	160	320	400
76 mm Gun Shells	60	120	150
.50 cal MG	4,400	16,000	16,000
25 mm MG	1,600	8,000	8,000
7.62 mm MG	30,000	40,000	40,000
20 mm; 25 mm; 30 mm Cannon Shells	8,000	18,500	19,500
RR-144A/AL Chaff Canisters	520	740	920
RR-188 Chaff Canisters	1,500	5,000	5,500
MK-214; MK-216 Chaff Canisters	72	90	108
MK-46 MOD 1C; MJU-8A/B; MJU-27A/B; MJU-32B; MJU-53B; SM-875/ALE Flares	520	740	920
MJU-7; MJU-10; MJU-206 Flares	1,500	5,000	5,500
AIM-7 Sparrow	4	6	8
AIM-9 Sidewinder	4	6	8
AIM-120 AMRAAM	4	6	8
RIM-7 Sea Sparrow/ RIM-116 RAM / **RIM-67 SM II ER**	2	4	6
PRI: Marianas Maritime > 3 nm **SEC: W-517**			
EER/IEER/AEER	103	106	115
5.56 mm; 7.62 mm; .50 cal; 40 mm	12,000	16,000	20,000

Table D-42: Summary of Ordnance Use by Training Area in the MIRC Study Area[1] (cont'd)

Training Area and Ordnance Type	Number of Rounds Per Year		
	No Action	Alternative 1	Alternative 2
PRI: W-517 SEC: Marianas Maritime > 50 nm; ATCAAs	**SINKEX**		
HARM	2	4	4
SLAM-ER	4	8	8
HARPOON	5	10	10
5" Gun Shells	400	800	800
HELLFIRE	2	4	4
MAVERICK	8	16	16
GBU-12	10	20	20
GBU-10	4	8	8
MK-48	1	2	2
Underwater Demolitions [100 lb NEW]	2	4	4
PRI: Agat Bay (20 lb NEW max) SEC: Apra Harbor (10 lb NEW max)	**Underwater Demolition**		
5 – 20 lb NEW	22	30	30
PRI: Agat Bay (20 lb NEW max) SEC: Piti (20 lb NEW max)	**Floating Mine Neutralization**		
5 – 20 lb NEW	8	20	20

1. Baseline ordnance expenditure estimates were made from review of FY03-07 Service records, databases, schedules, and estimates

Sonar Activity

Table D-43: Summary of Sonar Activity by Exercise Type in the MIRC Study Area

Exercise Type	No Action	Alternative 1	Alternative 2
Multi-Strike Group: One; [3] CSG; April – September; [10] Days	**Activity Guidelines Per CSG: [4] SQS-53C/D; [1] SQS-56 ; [2] Dips per hour; [1] EER/IEER/AEER per hour until 100; [16] DICASS per hour; Reset Time -12 hours**		
Events Per Year	0 or 1 (One Multi-Strike Group Exercise or One Joint Expeditionary Exercise)	1	1
SQS-53C/D	1705 hours	1705 hours	1705 hours
SQS-56	77 hours	77 hours	77 hours
AQS-22	288 dips	288 dips	288 dips
DICASS	1282	1282	1282
Sub BQQ	0	0	0
SINKEX : Two [2] Day Event	**Activity Guidelines: Sonar Hours in TRACKEX/TORPEX below**		
Events Per Year	1	2	2
DICASS	100	200	200
MK-48 (HE)	1	2	2
Joint Expeditionary: One [1] CSG + ESG; [10] Days	**Activity Guidelines: [3] SQS-53C/D; [1] SQS-56; Sonar Hours and Sonobuoys in TRACKEX/TORPEX below**		
Events Per Year	0 or 1 (One Multi-Strike Group Exercise or One Joint Expeditionary Exercise)	1	1
Fleet Strike Group: One [1] CSG; [7] Days	**Activity Guidelines: [4] SQS-53C/D; [1] SQS-56; Sonar Hours and Sonobuoys in TRACKEX/TORPEX below**		
Events Per Year	0	0	1
Integrated ASW: One [1] CSG; [5] Days	**Activity Guidelines: [4] SQS-53C/D; [1] SQS-56; Sonar Hours and Sonobuoys in TRACKEX/TORPEX below**		
Events Per Year	0	0	1

Table D-43: Summary of Sonar Activity by Exercise Type in the MIRC Study Area (cont'd)

Exercise Type	No Action	Alternative 1	Alternative 2
Ship Squadron ASW: One [1] DESRON; [5] Days	**Activity Guidelines: [4] SQS-53C/D; [1] SQS-56; Sonar Hours and Sonobuoys in TRACKEX/TORPEX below**		
Events Per Year	0	0	1
MAGTF Exercise (STOM/NEO)	**Activity Guidelines: [2] SQS-53C/D; [1] SQS-56; Sonar Hours and Sonobuoys in TRACKEX/TORPEX below**		
Events Per Year	1	4	4
ASW TRACKEX (SHIP) : One [1] Reset, One [1] Day Event	**Activity Guidelines: [2] SQS-53C/D, [1] SQS-56; Reset Time - 8 hours (sub target), 4 hours (non-sub target); [3] 53C/D, ½ Time Active, [1] 56, ¼ Time Active**		
Events Per Year	10	30	60
SQS-53 C/D	120 hours	360 hours	720 hours
SQS-56	20 hours	60 hours	120 hours
ASW TRACKEX (HELO) : One [1] Reset, One [1] Day Event	**Activity Guidelines: [2] SH-60B; [1] SH-60F 2 dips per hour; Reset Time - 8 hours (sub target), 4 hours (non-sub target)**		
Events Per Year	9	18	62
AQS-22	144 dips	288 dips	576 dips
DICASS	36	72	144
ASW TRACKEX (MPA) : One [1] Reset, [1] Day Per Event	**Activity Guidelines: [1] MPA; Reset Time - 8 hours (sub target), 4 hours (non-sub target)**		
Events Per Year	5	8	17
DICASS	50	80	170
EER/IEER/AEER	5	8	17
ASW TORPEX (SUB) : One [1] Reset, [1] Day Per Event; [1] EXTORP Per Event	**Activity Guidelines: [1] SSN or SSGN; Reset Time - 8 hours (sub target), 4 hours (non-sub target)**		
Events Per Year	5	10	12
Sub BQQ	6 hours	12 hours	15 hours
MK-48 EXTORP	20	40	48

Table D-43: Summary of Sonar Activity by Exercise Type in the MIRC Study Area (cont'd)

Exercise Type	No Action	Alternative 1	Alternative 2
ASW TORPEX (SHIP) : One [1] Reset, [1] Day Per Event; [1] REXTORP	**Activity Guidelines: [2] SQS-53C/D, [1] SQS-56; Reset Time - 8 hours (sub target), 4 hours (non-sub target); ½ Time Active**		
Events Per Year	0	3	6
SQS-53 C/D	0	8 hours	16 hours
SQS-56	0	4 hours	8 hours
REXTORP	0	3	6
ASW TORPEX (MPA/HELO) : One [1] Reset, One [1] Day Event; [1] REXTORP	**Activity Guidelines: [2] SH-60B; [1] SH-60F; [1] MPA; Reset Time - 8 hours (sub target), 4 hours (non-sub target)**		
Events Per Year	0	4	8
AQS-22	0	16 dips	32 dips
DICASS	0	20	40
REXTORP	0	4	8

This page intentionally left blank

APPENDIX E

WEAPON SYSTEMS

Descriptions of weapon systems used in the MIRC.

This Page Intentionally Left Blank

TABLE OF CONTENTS

LIST OF FIGURES

There are no figures in this section.

LIST OF TABLES

This page intentionally left blank.

Table E-1: Typical Missile Exercise Weapons Used in the Mariana Islands Range Complex

TYPE	CHARACTERISTICS				
	Weight	**Length**	**Diameter**	**Range**	**Propulsion**
Air-to-Air Missiles					
			Short Range		
Sidewinder (AIM-9)	84.4 kg (186 lb)	2.9 m (9 ft 6 in)	127 mm (5 in)	18.5 km (10 nm)	Solid fuel
			Medium Range		
Sparrow (AIM-7)	231 kg (510 lb)	3.6 m (11 ft 10 in)	203.2 mm (8 in)	55.6 km (30 nm)	Solid fuel
Slammer (AIM-120)	151 kg (335 lb)	3.7 m (12 ft)	18 cm (7 in)	33km (18 nm)	Solid fuel
			Air-to-Surface Missiles		
			Medium Range		
TOW (BGM-71)*	18.9 kg (41.67 lb)	1.16 m (3.81 ft)	0.152 m (0.50 ft)	3,750 m (2.02 nm)	Solid fuel
Hellfire (AGM-114)	45.77 kg (100.9 lb)	1.63 m (64 in)	17.78 cm (7 in)	8000 m (4.3 nm)	Solid fuel
Maverick (AGM-65)	136 kg (300 lb)	2.49 m (98 in)	30.48 cm (12 in)	27 km (12 nm)	Solid fuel
HARM (AGM-88)	366.1 kg (807 lb)	4.2 m (13 ft 9 in)	254 mm (10 in)	18.5 km (10 nm)	Solid fuel
			Extended Range		
Harpoon (AGM 84)	515.25 kg (1,145 lb}	3.84 m (12 ft 7 in)	24.29 cm (13.5 in)	111+ km (60+ nm)	Turbojet
SLAM-ER	635.04 kg (1,400 lb)	4.36 m (14 ft 4 in)	24.29 cm (13.5 in)	278+ km (150+ nm)	Turbojet
			Surface-to-Air Missiles		
Sea Sparrow (RIM-7)	225 kg (500 lb)	3.64 m (12 ft)	20.3 cm (8 in)	19+ km (10+ nm)	Solid fuel
RAM (RIM-116) Block 1	73.5 kg (162 lb)	278 cm (109.4 in)	12.7 cm (5 in)	7.5 km (4.5 nm)	Solid fuel
SM-2 ER (RIM-67)	1341 kg (2,980 lb)	7.9 m (26.2 ft)	1.6 m (5 ft 2 in)	185 km (100 nm)	Solid fuel

Source: U.S. Department of the Navy, 1998a

Notes:

* Describes the Variant BGM-71B.

Table E-2: Typical Aerial Target Drones in the Mariana Islands Range Complex

TYPE	CHARACTERISTICS			
	Length	Speed (Maximum)	Operational Altitude (Maximum)	Time on Station (Maximum)
Subsonic				
TALD/ITALD	2.34 m (7ft 8in)	Mach 0.84	12,200 m (40,000 ft)	23.2 minutes
BQM-74E	4 m (13 ft)	525 knots	12,308 m (40,000 ft)	68 minutes

Source: U.S. Department of the Navy, 1998a

Notes: N/A: Not Applicable; TALD: Tactical Air Launched Decoy; ITALD: Improved TALD.

Table E-3: Typical Existing Target Systems Used in the Mariana Islands Range Complex

Type	Category	Name	Propellant Type
Balloon			
	Aerial	Balloon	N/A
Surface			
	Floating	MK-58 (Smoke Float)	N/A
		Ship Hulk (TBD)	N/A
		Stationary Barge	N/A
		Radar Reflective Surface Balloon (Killer Tomato)	N/A
		Barrel on a Pallet	N/A
	Land	Hi-fidelity shapes (SAM Launcher)	N/A
		Paper Silhouette	N/A
Sub Surface			
	Self-propelled	EMATT	Battery
		MK-30	Battery

Source: U.S. Department of the Navy, 1988a; Notes: N/A Not Applicable

Table E-4: Typical Existing Weapons Used in the Mariana Islands Range Complex

Type	Category	Name	Propellant Type (Liquid/Solid)
Air Deployed Mines			
	Air	MK-62; MK-56 (non-explosive/inert)	N/A
Underwater Charges			
	NSW and EOD Divers	20 lb / 10 lb / 5lb NEW (C-4) charges	N/A
Missiles			
	Air	Captive Air Training Missile (CATM)-9	N/A

Table E-4: Typical Existing Weapons Used in the Mariana Islands Range Complex (cont'd)

Type	Category	Name	Propellant Type (Liquid/Solid)
	Air	Hellfire (AGM-114)	Solid
	Air	TOW (BGM-71)	Solid
	Air	Sparrow (AIM-7)	Solid
	Air	Sidewinder (AIM-9)	Solid
	Air	Slammer (AIM 120)	Solid
	Air	HARM (AGM-88)	Solid
	Air	SLAM ER	Turbojet
	Air/Ship/Undersea	Harpoon (A/R/UGM-84)	Turbojet
	Ship	Sea Sparrow (RIM-7)	Solid
	Ship	RAM (RIM-116)	Solid
	Ship	SM-2 ER (RIM-67)	Solid
Guns			
	Ship	Large Caliber Naval Guns (5" and 76mm)	N/A
	Ship	Mk-38 25 mm Machine Gun	N/A
	Ship	Phalanx/Vulcan (20mm)	N/A
	Ship	9 mm pistol	N/A
	Ship	5.56/7.62 mm/.50 caliber guns	N/A
	Ship	Small Caliber (M-16, M-4, M-249 squad automatic weapon, M-240G machine gun)	N/A
	Ship	M-40 sniper rifle (.308 cal)	N/A
	Air	Small Caliber (.50 cal, 7.62 mm, 9 mm, 5.56 mm, .308 cal)	N/A
	Air	20 mm cannon and 25 mm cannon	N/A
	Air	40mm Bofors and 105mm cannon (AC-130)	N/A
Bombs			
	Air	Mk-82 or GBU-30/38 (HE and NEPM)	N/A
	Air	Mk-83 or GBU-32 (HE and NEPM)	N/A
	Air	MK-84 or GBU-31 (HE)	N/A
	Air	GBU-10	N/A
	Air	GBU-12	N/A
	Air	GBU-16	N/A
	Air	M-117	N/A
	Air	BDU-33	N/A
	Air	BDU-50	N/A
	Air	BDU-56	N/A
	Air	BLU-111	N/A
	Air	LGTR (NEPM)	N/A
	Air	BDU-45 (NEPM)	N/A
	Air	MK-76 (NEPM)	N/A
Torpedoes			
	Sub	MK-48 and MK-48 EXTORP	Liquid

Source: Adapted from U.S. Department of the Navy, 1998a; Note: N/A Not Applicable.

Table E-5: Typical Electronic Warfare Assets Used in the Mariana Islands Range Complex

TYPE	CHARACTERISTICS	
	Frequency Bands	Power Output (Maximum)
Threat Simulators (Airborne)		
AN/AST6DPT-1(V)	Version V10 7.8-8.5 GHZ	15 MW
	Version V20 8.5-9.6 GHZ	20 MW
	Version V30 14-15.2 GHZ	25 MW
	Version V42 15.5-17.5 GHZ	30 MW
AN/AST 9	Version India (M) 8.5-9.6 GHZ	20 MW
	Version India (T) 8.5-9.6 GHZ	115 KW
	Version Juliet (M) 14-15.2 GHZ	25 MW
	Version Juliet (T) 14-15.2 GHZ	115 KW
Radar Jamming Systems (Airborne)		
AN/ALQ 167	Version V38 425 to 445 MHZ	800 W
	Version V39 902-928 MHZ	800 W
	Version V46 2.9-3.5 GHZ	800 W
	Version V15a/6X 9-10.2 GHZ	800 W
Communications Jamming System (Airborne)		
AN/USQ-113	Version V1 20-500 MHZ	400 W
Chaff (Passive system)		
RR-144A/AL	N/A	N/A
RR-188	N/A	N/A
MK-214	N/A	N/A
MK-216	N/A	N/A
Flares (Infrared Countermeasures)		
Mk-46 MOD 1C	N/A	N/A
MJU-8A/B	N/A	N/A
MJU-27A/B	N/A	N/A
MJU-32B	N/A	N/A
MJU-53B	N/A	N/A
MJU-7	N/A	N/A
MJU-10	N/A	N/A
MJU-24	N/A	N/A
MJU-206	N/A	N/A
SM-875/ALE	N/A	N/A

Source: Adapted from U.S. Department of the Navy, 1998a.

APPENDIX F

MARINE MAMMAL MODELING

This section contains a description of the modeling performed of MIRC noise sources.

This Page Intentionally Left Blank

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

APPENDIX F Marine Mammal Modeling

F.1 Background and Overview

All marine mammals are protected under the Marine Mammal Protection Act (MMPA). The MMPA prohibits, with certain exceptions, the take of marine mammals in U.S. waters and by U.S. citizens on the high seas, and the importation of marine mammals and marine mammal products into the United States.

The Endangered Species Act of 1973 (ESA) provides for the conservation of species that are endangered or threatened throughout all or a significant portion of their range, and the conservation of their ecosystems. A species is considered endangered if it is in danger of extinction throughout all or a significant portion of its range. A species is considered threatened if it is likely to become an endangered species within the foreseeable future. There are marine mammals, already protected under MMPA, listed as either endangered or threatened under ESA, and afforded special protections. Actions involving sound in the water include the potential to harass marine animals in the surrounding waters. Demonstration of compliance with MMPA and the ESA, using best available science, has been assessed using criteria and thresholds accepted or negotiated, and described here.

Sections of the MMPA (16 United States Code [U.S.C.] 1361 et seq.) direct the Secretary of Commerce to allow, upon request, the incidental, but not intentional, taking of small numbers of marine mammals by U.S. citizens who engage in a specified activity, other than commercial fishing, within a specified geographical region. Through a specific process, if certain findings are made and regulations are issued, or if the taking is limited to harassment, notice of a proposed authorization is provided to the public for review.

Authorization for incidental takings may be granted if the National Marine Fisheries Service (NMFS) finds that the taking will have no more than a negligible impact on the species or stock(s), will not have an unmitigable adverse impact on the availability of the species or stock(s) for subsistence uses, and that the permissible methods of taking, and requirements pertaining to the mitigation, monitoring, and reporting of such taking are set forth.

NMFS has defined negligible impact in 50 Code of Federal Regulations (CFR) 216.103 as an impact resulting from the specified activity that cannot be reasonably expected to, and is not reasonably likely to, adversely affect the species or stock through effects on annual rates of recruitment or survival.

Subsection 101(a) (5)(D) of the MMPA established an expedited process by which citizens of the United States can apply for an authorization to incidentally take small numbers of marine mammals by harassment. The National Defense Authorization Act of 2004 (NDAA) (Public Law 108-136) removed the small numbers limitation and amended the definition of "harassment" as it applies to a military readiness activity to read as follows:

> (i) *any act that injures or has the significant potential to injure a marine mammal or marine mammal stock in the wild [Level A Harassment]; or*
>
> (ii) *any act that disturbs or is likely to disturb a marine mammal or marine mammal stock in the wild by causing disruption of natural behavioral patterns, including, but not limited to, migration, surfacing, nursing, breeding, feeding, or sheltering, to a point where such behavioral patterns are abandoned or significantly altered [Level B Harassment].*

The sound sources will be located in an area that is inhabited by species listed as threatened or endangered under the Endangered Species Act (ESA, 16 USC §§ 1531-1543). Operation of the sound sources, that is, transmission of acoustic signals in the water column, could potentially cause harm or harassment to listed species.

"Harm" defined under ESA regulations is "…an act which actually kills or injures…" (50 CFR 222.102) listed species. "Harassment" is an "intentional or negligent act or omission which creates the likelihood of injury to wildlife by annoying it to such an extent as to significantly disrupt normal behavioral patterns which include, but are not limited to, breeding, feeding, or sheltering" (50 CFR 17.3).

Level A harassment criteria and thresholds under MMPA are appropriate to apply as "harm" criteria and thresholds under ESA. Analysis that predicts Level A harassment under MMPA will occur as a result of the proposed action would correspond to harm to listed species under ESA. Level B harassment criteria and thresholds under MMPA are appropriate to apply as harassment criteria and thresholds under ESA.

If a federal agency determines that its proposed action "may affect" a listed species, it is required to consult, either formally or informally, with the appropriate regulator. There is no permit issuance under ESA, rather consultation occurs among the cognizant federal agencies under § 7 of the ESA. Such consultations would likely be concluded favorably, subject to requirements that the activity will not appreciably reduce the likelihood of the species' survival and recovery and impacts are minimized and mitigated. If appropriate, the Navy would initiate formal interagency consultation by submitting a Biological Assessment to NMFS, detailing the proposed action's potential effects on listed species and their designated critical habitats. Consultation would conclude with NMFS' issuance of a Biological Opinion that addresses the issues of whether the project can be expected to jeopardize the continued existence of listed species or result in the destruction or adverse modification of critical habitat.

F.2 Acoustic Sources

The MIRC acoustic sources are categorized as either broadband (producing sound over a wide frequency band) or narrowband (producing sound over a frequency band that that is small in comparison to the center frequency). In general, the narrowband sources in this exercise are Anti-Submarine Warfare (ASW) sonars and the broadband sources are explosives. This delineation of source types has a couple of implications. First, the transmission loss used to determine the impact ranges of narrowband ASW sonars can be adequately characterized by model estimates at a single frequency. Broadband explosives, on the other hand, produce significant acoustic energy across several frequency decades of bandwidth. Propagation loss is sufficiently sensitive to frequency as to require model estimates at several frequencies over such a wide band.

Second, the types of sources have different sets of harassment metrics and thresholds. Energy metrics are defined for both types. However, explosives are impulsive sources that produce a shock wave that dictates additional pressure-related metrics (peak pressure and positive impulse). Detailed descriptions of both types of sources are provided in the following subsections.

F.2.1 Sonars

F.2.1.1 Sonar Device Descriptions

The majority of training and research, development, testing, and evaluation activities in the MIRC involve five types of narrowband sonars. Exposure estimates are calculated for each sonar according to the manner in which it operates. For example, the AN/SQS 53 and AN/SQS 56 are hull-mounted, mid-frequency active (MFA) surface ship sonars that operate for many hours at a time (although sound is output—the "active" portion—only a small fraction of that time), so it is most useful to calculate and report surface ship sonar exposures per hour of operation. The BQQ-10 submarine sonar is also reported per hour of operation. However, the submarine sonar is modeled as pinging only twice per hour. The AN/AQS-22 is a helicopter-deployed sonar, which is lowered into the water, pings several times, and then moves to a new location; this sonar is used for localization and tracking a suspected contact as opposed to searching for contacts. For the AN/AQS-22, it is most helpful to calculate and report exposures per dip. The AN/SSQ-62 is a sonobuoy that is dropped into the water from an aircraft or helicopter and pings about 10 to 30 times in an hour. For the AN/SSQ-62, it is most helpful to calculate and report exposures per sonobuoy. For the MK-48 torpedo, the sonar is modeled for a typical training event and the MK-48 reporting metric is the number of torpedo runs. Table F-1 presents the deployment platform, frequency class, the metric for reporting exposures, and the units for each sonar.

Table F-1: Active Sonars Modeled in the MIRC

Sonar	Description	Frequency Class	Exposures Reported	Units per hour
MK-48	Torpedo sonar	High-frequency	Per torpedo	One torpedo run
AN/SQS-53	Surface ship sonar	Mid-frequency	Per hour	120 sonar pings
AN/SQS-56	Surface ship sonar	Mid-frequency	Per hour	120 sonar pings
AN/SSQ-62	Sonobuoy sonar	Mid-frequency	Per sonobuoy	8 sonobuoys
AN/SSQ-125 AEER	Sonobuoy sonar	Mid-frequency	Per sonobuoy	8 sonobuoys
AN/AQS-22	Helicopter-dipping sonar	Mid-frequency	Per dip	2 dips
BQQ-10[1]	Submarine sonar	Mid-frequency	Per hour	2 sonar pings

Note:[1] BQQ-10 is modeled as representative of all MFA submarine sonar (BQQ-10, BQQ-5, and BSY-1)

Note that MK-48 source described here is the high-frequency active (HFA) sonar on the torpedo; the explosive source of the detonating torpedo is described in the next subsection.

The acoustic modeling that is necessary to support the take estimates for each of these sonars relies upon a generalized description of the manner of the sonar's operating modes. This description includes the following:

- "Effective" energy source level – This is the level relative to 1 μPa^2-s of the integral over frequency and time of the square of the pressure and is given by the total energy level across the band of the source, scaled by the pulse length (10 $\log_{10}$ [pulse length]).
- Source depth – Depth of the source in meters.
- Nominal frequency – Typically the center band of the source emission. These are frequencies that have been reported in open literature and are used to avoid classification issues. Differences between these nominal values and actual source frequencies are small enough to be of little consequence to the output impact volumes.

- Source directivity – The source beam is modeled as the product of a horizontal beam pattern and a vertical beam pattern. Two parameters define the horizontal beam pattern:
  - Horizontal beam width – Width of the source beam (degrees) in the horizontal plane (assumed constant for all horizontal steer directions).
  - Horizontal steer direction – Direction in the horizontal in which the beam is steered relative to the direction in which the platform is heading

  The horizontal beam is assumed to have constant level across the width of the beam with flat, 20-dB down sidelobes at all other angles.

  Similarly, two parameters define the vertical beam pattern:

  - Vertical beam width – Width of the source beam (degrees) in the vertical plane measured at the 3-dB down point. (assumed constant for all vertical steer directions).
  - Vertical steer direction – Direction in the vertical plane that the beam is steered relative to the horizontal (upward looking angles are positive).

  To avoid sharp transitions that a rectangular beam might introduce, the power response at vertical angle □ is

  $$\text{Power} = \max \{ \sin^2 [n(□_s - □)] / [n \sin (□_s - □)]^2,\ 0.01 \},$$

  Where $□_s$ is the vertical beam steer direction, and
  $n = 2*L/\lambda$ (L = array length, λ = wavelength),

  The beamwidth of a line source is determined by n (the length of the array in half-wavelengths) as $□_w = 180^o/n$.

- Ping spacing – Distance between pings. For most sources this is generally just the product of the speed of advance of the platform and the repetition rate of the sonar. Animal motion is generally of no consequence as long as the source motion is greater than the speed of the animal (nominally, 3 knots). For stationary (or nearly stationary) sources, the “average” speed of the animal is used in place of the platform speed. The attendant assumption is that the animals are all moving in the same constant direction.

Many of the actual parameters and capabilities of these sonars are classified. Parameters used for modeling were derived to be as representative as possible taking into account the manner with which the sonar would be used in various training scenarios. However, when there was a wide range of potential modeling input values, the default was to model using a nominal parameter likely to result in the most impact, so that the model would err towards the maximum potential exposures.

For the sources that are essentially stationary (AN/SSQ-62 and AN/AQS-22), emission spacing is the product of the ping cycle time and the average animal speed.

F.2.1.2 Metrics for Physiological Effect Thresholds

Effect thresholds used for acoustic impact modeling in this document are expressed in terms of Energy Flux Density (EFD) / Sound Exposure Level (SEL), which is total energy received over time in an area, or in terms of Sound Pressure Level (SPL), which is the level (root mean square) without reference to any time component for the exposure at that level. Marine and terrestrial mammal data show that, for continuous-type sounds of interest, Temporary Threshold Shift (TTS) and Permanent Threshold Shift (PTS) are more closely related to the energy in the sound exposure than to the exposure SPL.

The Energy Level (EL) for each individual ping is calculated from the following equation:

EL = SPL + 10log10(duration)

The EL includes both the ping SPL and duration. Longer-duration pings and/or higher-SPL pings will have a higher EL.

If an animal is exposed to multiple pings, the energy flux density in each individual ping is summed to calculate the total EL. Since mammalian Threshold Shift (TS) data show less effect from intermittent exposures compared to continuous exposures with the same energy (Ward, 1997), basing the effect thresholds on the total received EL is a conservative approach for treating multiple pings; in reality, some recovery will occur between pings and lessen the effect of a particular exposure. Therefore, estimates are conservative because recovery is not taken into account (given that generally applicable recovery times have not been experimentally established) and as a result, intermittent exposures from sonar are modeled as if they were continuous exposures.

The total EL depends on the SPL, duration, and number of pings received. The TTS and PTS thresholds do not imply any specific SPL, duration, or number of pings. The SPL and duration of each received ping are used to calculate the total EL and determine whether the received EL meets or exceeds the effect thresholds. For example, the TTS threshold would be reached through any of the following exposures:

- A single ping with SPL = 195 dB re 1 μPa and duration = 1 second.
- A single ping with SPL = 192 dB re 1 μPa and duration = 2 seconds.
- Two pings with SPL = 192 dB re 1 μPa and duration = 1 second.
- Two pings with SPL = 189 dB re 1 μPa and duration = 2 seconds.

F.2.1.3 Derivation of an Effects Threshold for Marine Mammals Based on Energy Flux Density

As described in detail in Section 3.7 of the EIS/OEIS, SEL (EFD level) exposure threshold established for onset-TTS is 195 dB re 1 μPa^2-s. This result is corroborated by the short-duration tone data of Finneran et al. (2000, 2003) and the long-duration sound data from Nachtigall et al. (2003a, b). Together, these data demonstrate that TTS in small odontocetes is correlated with the received EL and that onset-TTS exposures are fit well by an equal-energy line passing through 195 dB re 1 μPa^2-s. Absent any additional data for other species and being that it is likely that small odontocetes are more sensitive to the mid-frequency active/high-frequency active (MFA/HFA) frequency levels of concern, this threshold is used for analysis for all cetacea.

The PTS thresholds established for use in this analysis are based on a 20 dB increase in exposure EL over that required for onset-TTS. The 20 dB value is based on estimates from terrestrial mammal data of PTS occurring at 40 dB or more of TS, and on TS growth occurring at a rate of 1.6 dB/dB increase in exposure EL. This is conservative because: (1) 40 dB of TS is actually an upper limit for TTS used to approximate onset-PTS, and (2) the 1.6 dB/dB growth rate is the highest observed in the data from Ward et al. (1958, 1959). Using this estimation method (20 dB up from onset-TTS) for the Mariana Islands Range Complex

(MIRC) analysis, the PTS threshold for cetacea is 215 dB re 1µPa^2-s, and for monk seals it is 224 dB re 1µPa^2-s.

F.2.1.4 Derivation of a Behavioral Effect Threshold for Marine Mammals Based on Sound Pressure Level (SPL)

Over the past several years, the Navy and NMFS have worked on developing alternative criteria to replace and/or to supplement the acoustic thresholds used in the past to estimate the probability of marine mammals being behaviorally harassed by received levels of MFA and HFA sonar. Following publication of the Draft Environmental Impact Statement/Overseas Environmental Impact Statement (EIS/OEIS), the Navy continued working with NMFS to refine a mathematically representative curve for assessment of behavioral effects modeling associated with the use of MFA/HFA sonar. As detailed in Section 4.1.2, the NMFS Office of Protected Resources made the decision to use a risk function and applicable input parameters to estimate the probability of behavioral responses that NMFS would classify as harassment for the purposes of the MMPA given exposure to specific received levels of MFA/HFA sonar. This decision was based on the recommendation of the two NMFS scientists, consideration of the independent reviews from six scientists, and NMFS MMPA regulations affecting the Navy's use of Surveillance Towed Array Sensor System Low-Frequency Active (SURTASS LFA) sonar (U.S. Department of the Navy, 2002; National Oceanic and Atmospheric Administration, 2007).

The particular acoustic risk function developed by the Navy and NMFS is derived from a solution in Feller (1968) with input parameters modified by NMFS for MFA/HFA sonar for mysticetes, odontocetes, and pinnipeds. In order to represent a probability of risk in developing this function, the function would have a value near zero at very low exposures, and a value near one for very high exposures. One class of functions that satisfies this criterion is cumulative probability distributions, a type of cumulative distribution function. In selecting a particular functional expression for risk, several criteria were identified:

- The function must use parameters to focus discussion on areas of uncertainty;
- The function should contain a limited number of parameters;
- The function should be capable of accurately fitting experimental data; and
- The function should be reasonably convenient for algebraic manipulations.

As described in U.S. Department of the Navy (2001), the mathematical function below is adapted from a solution in Feller (1968):

$$R = \frac{1 - \left(\frac{L-B}{K}\right)^{-A}}{1 - \left(\frac{L-B}{K}\right)^{-2A}}$$

Where: R = risk (0 – 1.0);

L = Received Level (RL) in dB

B = basement RL in dB (120 dB)

K = the RL increment above basement in dB at which there is 50 percent risk

A = risk transition sharpness parameter (10)

It is important to note that the probabilities associated with acoustic modeling do not represent an individual's probability of responding; they identify the proportion of an exposed population (as represented by an evenly distributed density of marine mammals per unit area) that is likely to respond to an exposure. In addition, modeling does not take into account reductions from any of the Navy's standard protective mitigation measures which should significantly reduce or eliminate actual exposures that may have otherwise occurred during training.

F.2.2 Explosives

Explosives detonated underwater introduce loud, impulsive, broadband sounds into the marine environment. The acoustic energy of an explosive is, generally, much greater than that of a sonar, so careful treatment of them is important, since they have the potential to injure. Three source parameters influence the effect of an explosive: the weight of the explosive warhead, the type of explosive material, and the detonation depth. The net explosive weight (NEW) accounts for the first two parameters. The NEW of an explosive is the weight of only the explosive material in a given round, referenced to the explosive power of trinitrotoluene (TNT).

F.2.2.1 Explosive Source Descriptions

The detonation depth of an explosive is particularly important due to a propagation effect known as surface-image interference. For sources located near the sea surface, a distinct interference pattern arises from the coherent sum of the two paths that differ only by a single reflection from the pressure-release surface. As the source depth and/or the source frequency decreases, these two paths increasingly, destructively interfere with each other, reaching total cancellation at the surface (barring surface-reflection scattering loss). Since most MIRC explosive sources are munitions that detonate essentially upon impact, the effective source depths are quite shallow, and therefore the surface-image interference effect can be pronounced. In order to limit the cancellation effect (and thereby provide exposure estimates that tend toward the worst case), relatively deep detonation depths are used. Consistent with earlier Virtual At Sea Training System/Integrated Maritime Portable Acoustic Scoring and Simulator Buoy System VAST/IMPASS modeling, a source depth of 1 foot is used for gunnery rounds. For the missile and bombs, a source depth of 2 meters (m) is used. For Extended Echo Ranging/Improved Extended Echo Ranging (EER/IEER) a nominal depth of 20 m is used to ensure that the source is located within any significant surface duct, resulting in maximum potential exposures. Table F-2 gives the ordnances of interest in the MIRC, their NEWs, and their expected detonation depths.

Table F-2: Explosive Sources Modeled in MIRC

Ordnance	Net Explosive Weight for Modeling	Detonation Depth for Modeling
5" Naval gunfire	9.54 lbs	1 ft
76 mm Rounds	1.6 lbs	1 ft
Maverick	78.5 lbs	2 m
Harpoon	448 lbs	2 m
MK-82	238 lbs	2 m
MK-83	574 lbs	2 m
MK-48	851 lbs	50 ft
Demolition Charges	10 lbs	Bottom
EER/IEER	5 lbs	20 m

The exposures expected to result from these ordnances are generally computed on a per in-water explosive basis. The cumulative effect of a series of explosives can often be derived by simple addition if the detonations are spaced widely in time or space, allowing for sufficient animal movement as to ensure that a different population of animals is harassed by each ordnance detonation. There may be rare occasions when multiple successive explosions (MSEs) are part of a static location event. For these events, the Churchill FEIS approach was extended to cover MSE events occurring at the same location. For MSE exposures, accumulated energy over the entire training time is the natural extension for energy thresholds since energy accumulates with each subsequent shot; this is consistent with the treatment of multiple arrivals in Churchill. For positive impulse, it is consistent with the Churchill FEIS to use the maximum value over all impulses received.

For MSEs, the acoustic criterion for non-TTS behavioral disturbance is used to account for behavioral effects significant enough to be judged as harassment, but occurring at lower sound energy levels than those that may cause TTS. For MSE events potential behavioral disturbances were estimated by extrapolation from the acoustic modeling results for the explosives TTS threshold (182 dB re 1 μPa^2-s in any 1/3 octave band). To account for the 5 dB lower non-TTS threshold, a factor of 3.17 was applied to the TTS modeled numbers in order to extrapolate the number of non-TTS exposures estimated for MSE events. This multiplication factor is used to calculate the increased area represented by the difference between the 177 dB non-TTS threshold and the modeled 182 dB threshold. The factor is based on the increased range 5 dB would propagate (assuming spherical spreading), where the range increases by approximately 1.78 times, resulting in a circular area increase of approximately 3.17 times that of the modeled results at 182 dB.

A special case in which simple addition of the exposure estimates may not be appropriate is addressed by the modeling of a “representative” Sink Exercise (SINKEX). In a SINKEX, a decommissioned surface ship is towed to a specified deep-water location and there used as a target for a variety of weapons. Although no two SINKEXs are ever the same, a representative case derived from past exercises is described in the *Programmatic SINKEX Overseas Environmental Assessment* (March 2006) for the Western North Atlantic.

In a SINKEX, weapons are typically fired in order of decreasing range from the source with weapons fired until the target is sunk. A torpedo is used after all munitions have been expended if the target is still afloat. Since the target may sink at any time during the exercise, the actual number of weapons used can vary widely. In the representative case, however, all of the ordnances are assumed expended; this represents the worst case with maximum exposure.

The sequence of weapons firing for the representative SINKEX is described in Table F-3. Guided weapons are nearly 100 percent accurate and are modeled as hitting the target (that is, no underwater acoustic effect) in all but two cases: (1) the Maverick is modeled as a miss to represent the occasional miss, and (2) the MK-48 torpedo intentionally detonates in the water column immediately below the hull of the target. Unguided weapons are more frequently off-target and are modeled according to the statistical hit/miss ratios. Note that these hit/miss ratios are artificially low in order to demonstrate a worst-case scenario; they should not be taken as indicative of weapon or platform reliability.

Table F-3: Representative SINKEX Weapons Firing Sequence

Time (Local)	Event Description
0900	Range Control Officer receives reports that the exercise area is clear of non-participant ship traffic, marine mammals, and sea turtles.
0909	Hellfire missile fired, hits target.
0915	2 HARM missiles fired, both hit target (5 minutes apart).
0930	1 Penguin missile fired, hits target.
0940	3 Maverick missiles fired, 2 hit target, 1 misses (5 minutes apart).
1145	1 SM-1 fired, hits target.
1147	1 SM-2 fired, hits target.
1205	5 Harpoon missiles fired, all hit target (1 minute apart).
1300-1335	7 live and 3 inert MK 82 bombs dropped – 7 hit target, 2 live and 1 inert miss target (4 minutes apart).
1355-1410	4 MK 83 bombs dropped – 3 hit target, 1 misses target (5 minutes apart).
1500	Surface gunfire commences – 400 5-inch rounds fired (one every 6 seconds), 280 hit target, 120 miss target.
1700	MK 48 Torpedo fired, hits, and sinks target.

F.2.2.2 Explosive Source Criteria

For explosions of ordnance planned for use in the Mariana Islands Range Complex (MIRC), in the absence of any mitigation or monitoring measures, there is a very small chance that a marine mammal could be injured or killed when exposed to the energy generated from an explosive force. Analysis of noise impacts is based on criteria and thresholds initially presented in U.S. Navy Environmental Impact Statements for ship shock trials of the Seawolf submarine and the Winston Churchill (DDG 81), and subsequently adopted by NMFS. Explosive source criteria thresholds are presented in Table F-4.

Non-lethal injurious impacts (Level A Harassment) are defined in those documents as tympanic membrane (TM) rupture and the onset of slight lung injury. The threshold for Level A Harassment corresponds to a 50-percent rate of TM rupture, which can be stated in terms of an energy flux density (EFD) value of 205 dB re 1 μPa^2-s. TM rupture is well-correlated with permanent hearing impairment. Ketten (1998) indicates a 30-percent incidence of permanent threshold shift (PTS) at the same threshold.

Table F-4: Level A and B Harassment Threshold–Explosives

Threshold Type (Explosives)	Threshold Level
Level A – 50 percent Eardrum rupture	205 dB
Temporary Threshold Shift (TTS) (peak one-third octave energy)	182 dB
Non-TTS Threshold for Multiple Successive Explosions (peak one-third octave energy)	177 dB
Temporary Threshold Shift (TTS) (peak pressure)	23 psi
Level A – Slight lung injury (positive impulse)	13 psi-ms
Mortality – 1 percent Mortal lung injury (positive impulse)	31 psi-ms

The criteria for onset of slight lung injury were established using partial impulse because the impulse of an underwater blast wave was the parameter that governed damage during a study using mammals, not peak pressure or energy (Yelverton, 1981). Goertner (1982) determined a way to calculate impulse values for injury at greater depths, known as the Goertner "modified" impulse pressure. Those values are valid only near the surface because as hydrostatic pressure increases with depth, organs like the lung, filled with air, compress. Therefore the "modified" impulse pressure thresholds vary from the shallow depth starting point as a function of depth.

The shallow depth starting points for calculation of the "modified" impulse pressures are mass-dependent values derived from empirical data for underwater blast injury (Yelverton, 1981). During the calculations, the lowest impulse and body mass for which slight, and then extensive, lung injury found during a previous study (Yelverton et al, 1973) were used to determine the positive impulse that may cause lung injury. The Goertner model is sensitive to mammal weight such that smaller masses have lower thresholds for positive impulse so injury and harassment will be predicted at greater distances from the source for them. Impulse thresholds of 13.0 and 31.0 psi-ms, found to cause slight and extensive injury in a dolphin calf, were used as thresholds in the analysis contained in this document.

Level B (non-injurious) Harassment includes temporary (auditory) threshold shift (TTS), a slight, recoverable loss of hearing sensitivity. One criterion used for TTS, the total energy flux density of the signal, is a threshold of 182 dB re 1 μPa^2-s maximum EFD level in any 1/3-octave band above 100 Hz for toothed whales (e.g., dolphins). A second criterion, a maximum allowable peak pressure of 23 psi, has recently been established by NMFS to provide a more conservative range for TTS when the explosive or animal approaches the sea surface, in which case explosive energy is reduced, but the peak pressure is not. NMFS applies the more conservative of these two.

F.3 Environmental Provinces

Propagation loss ultimately determines the extent of the Zone of Influence (ZOI) for a particular source activity. In turn, propagation loss as a function of range responds to a number of environmental parameters:

- Water depth
- Sound speed variability throughout the water column
- Bottom geo-acoustic properties, and
- Surface roughness, as determined by wind speed

Due to the importance that propagation loss plays in ASW, the Navy has, over the last four to five decades, invested heavily in measuring and modeling these environmental parameters. The result of this effort is the following collection of global databases of these environmental parameters, which are accepted as standards for Navy modeling efforts.

- Water depth – Digital Bathymetry Data Base Variable Resolution (DBDBV)
- Sound speed – Generalized Digital Environmental Model (GDEM)
- Bottom loss – Low-Frequency Bottom Loss (LFBL), Sediment Thickness Database, and High-Frequency Bottom Loss (HFBL), and
- Wind speed – U.S. Navy Marine Climatic Atlas of the World

This section provides a discussion of the relative impact of these various environmental parameters. These examples then are used as guidance for determining environmental provinces (that is, regions in which the environmental parameters are relatively homogenous and can be represented by a single set of environmental parameters) within the MIRC.

F.3.1 Impact of Environmental Parameters

Within a typical operating area, the environmental parameter that tends to vary the most is bathymetry. It is not unusual for water depths to vary by an order of magnitude or more, resulting in significant impacts upon the ZOI calculations. Bottom loss can also vary considerably over typical operating areas, but its impact on ZOI calculations tends to be limited to waters on the continental shelf and the upper portion of the slope. Generally, the primary propagation paths in deep water, from the source to most of the ZOI volume, do not involve any interaction with bottom. In shallow water, particularly if the sound velocity profile directs all propagation paths to interact with the bottom, bottom loss variability can play a larger role.

The spatial variability of the sound speed field is generally small over operating areas of typical size. The presence of a strong oceanographic front is a noteworthy exception to this rule. To a lesser extent, variability in the depth and strength of a surface duct can be of some importance. In the mid-latitudes, seasonal variation often provides the most significant variation in the sound speed field. For this reason, both summer and winter profiles are modeled for each selected environment.

F.3.2 Environmental Provincing Methodology

The underwater acoustic environment can be quite variable over ranges in excess of 10 kilometers. For ASW applications, ranges of interest are often sufficiently large as to warrant the modeling of the spatial variability of the environment. In the propagation loss calculations, each of the environmental parameters is allowed to vary (either continuously or discretely) along the path from acoustic source to receiver. In such applications, each propagation loss calculation is conditioned upon the particular locations of the source and receiver.

On the other hand, the range of interest for marine animal harassment by most Naval activities is more limited. This reduces the importance of the exact location of source and marine animal and makes the modeling required more manageable in scope.

In lieu of trying to model every environmental profile that can be encountered in an operating area, this effort utilizes a limited set of representative environments. Each environment is characterized by a fixed water depth, sound velocity profile, and bottom loss type. The operating area is then partitioned into homogeneous regions (or provinces) and the most appropriately representative environment is assigned to each. This process is aided by some initial provincing of the individual environmental parameters. The Navy-standard high-frequency bottom loss database in its native form is globally partitioned into nine classes. Low-frequency bottom loss is likewise provinced in its native form, although it is not considered in the process of selecting environmental provinces. Only the broadband sources produce acoustic energy at the frequencies of interest for low-frequency bottom loss (typically less than 1 kHz); even for those sources the low-frequency acoustic energy is secondary to the energy above 1 kHz. The Navy-standard sound velocity profiles database is also available as a provinced subset. Only the Navy-standard bathymetry database varies continuously over the world's oceans. However, even this environmental parameter is easily provinced by selecting a finite set of water depth intervals. For this analysis "octave-spaced" intervals (10, 20, 50, 100, 200, 500, 1,000, 2,000, and 5,000 m) provide an adequate sampling of water depth dependence.

ZOI volumes are then computed using propagation loss estimates derived for the representative environments. Finally, a weighted average of the ZOI volumes is taken over all representative environments; the weighting factor is proportional to the geographic area spanned by the environmental province.

The selection of representative environments is subjective. However, the uncertainty introduced by this subjectivity can be mitigated by selecting more environments and by selecting the environments that occur most frequently over the operating area of interest.

As discussed in the previous subsection, ZOI estimates are most sensitive to water depth. Unless otherwise warranted, at least one representative environment is selected in each bathymetry province. Within a bathymetry province, additional representative environments are selected as needed to meet the following requirements.

- In shallow water (less than 1,000 meters), bottom interactions occur at shorter ranges and more frequently; thus significant variations in bottom loss need to be represented.
- Surface ducts provide an efficient propagation channel that can greatly influence ZOI estimates. Variations in the mixed layer depth need to be accounted for if the water is deep enough to support the full extent of the surface duct.

Depending upon the size and complexity of the operating area, the number of environmental provinces tends to range from 5 to 20.

F.3.3 Description of Environmental Provinces

The MIRC encompasses a large area about the Mariana Islands. For this analysis, the general operating area is bounded to the north and south by latitude lines of 7°N and 20°N and to the east and west by meridians of 138°E and 150°E.

7° 0' 30.07"	149° 16' 14.85"
6° 59' 24.6"	138° 1' 29.72"
20° 0' 24.56"	138° 0' 11.24"
20° 3' 27.55"	149° 17' 41.03"

SINKEX operations may occur anywhere within the general operating area as long as the water depth is greater than 1,000 fathoms and the nearest land is at least 50 nm away. This SINKEX region is partitioned into three sub-areas as described below.

- SINKEX East: An area east of Guam; bounded in latitude by 14° N and 16° N, and in longitude by 146° 30'E and 149° 12'E.
- SINKEX South: All of Warning Area 517 that is more than 50 nm offshore. W-517 is an irregularly-shaped region with the following vertices:

  13°-10'N 144°-30'E

  13°-10'N 144°-42'E

  12°-50'N 144°-45'E

  11°-00'N 144°-45'E

  11°-00'N 143°-00'E

  11°-45'N 143°-00'E

  11°-50'N 144°-30'E
- SINKEX General: All suitable SINKEX areas other than SINKEX East and SINKEX South.

The acoustic sonars described in subsection A.2 are deployed throughout the general operating area. The explosive sources, other than demolition charges, are limited to the three SINKEX sub-areas. The use of demolition charges is limited to Agat Bay and Outer Apra Harbor inshore areas.

This subsection describes the representative environmental provinces selected for the MIRC. For all of these provinces, the average wind speed, winter and summer, is 11 knots.

The general operating area of the MIRC contains a total of 9 distinct environmental provinces. These represent various combinations of five bathymetry regions, 10 Sound Velocity Profile (SVP) provinces, and 6 High-Frequency Bottom Loss (HFBL) regions.

The bathymetry provinces represent depths ranging from 200 meters to typical deep-water depths (more than 5,000 meters). Nearly all of the MIRC is characterized as deep-water (depths of 2,000 meters or more). The remaining water depths (1,000 meters and less) provide only small contributions to the analysis. The distribution of the bathymetry provinces over the MIRC is provided in Table F-5.

Table F-5: Distribution of Bathymetry Provinces in MIRC

Province Depth (m)	Frequency of Occurrence
200	0.23 %
500	0.64 %
1,000	1.98 %
2,000	17.69 %
5,000	79.46 %

Ten SVP provinces describe the sound speed field in the MIRC; however, the variability among the 10 provinces is relatively small as demonstrated by the summer profiles presented in Figure F-1. The dominant difference among the profiles is the steepness of the thermocline.

The seasonal variation is likewise of limited dynamic range, as might be expect given that the range is located in temperate waters. The surface sound speed of the winter profile is only a few m/s slower than the summer profile as depicted in Figure F-2. Both seasons exhibit a well-formed surface duct with average mixed layers of approximately 50 meters and 75 meters in the summer and winter, respectively.

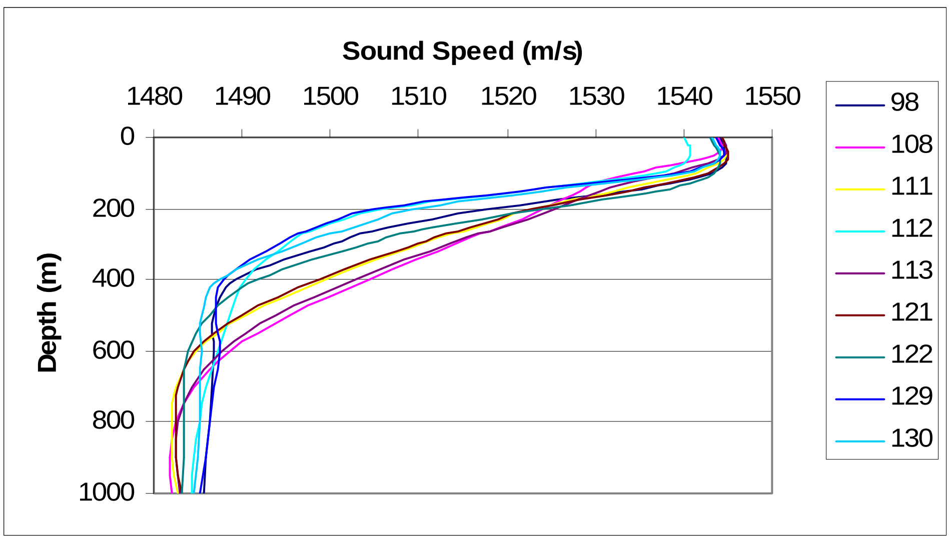


Figure F-1: Summer SVPs in MIRC

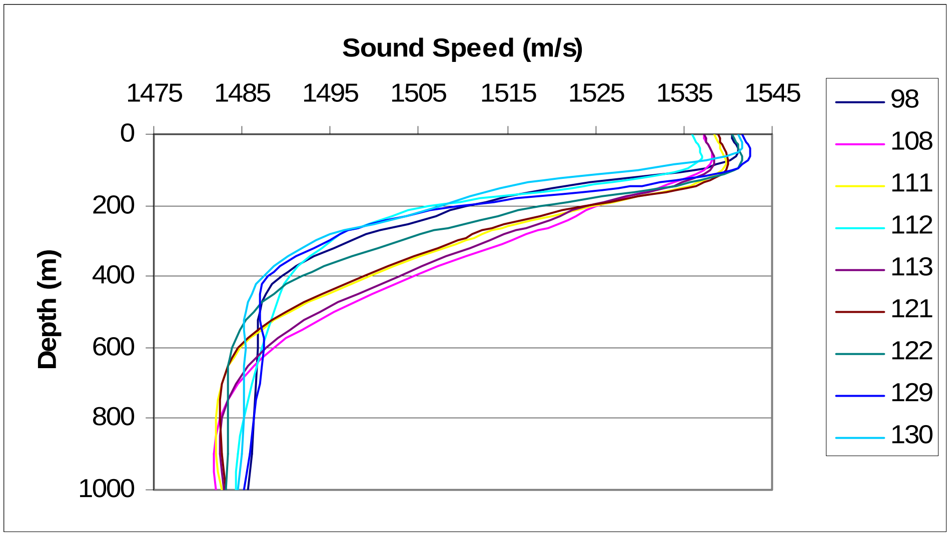


Figure F-2: Winter SVPs in MIRC.

The distribution of the ten SVP provinces across the MIRC is provided in Table F-6.

Table F-6: Distribution of SVP Provinces in MIRC

SVP Province	Frequency of Occurrence
98	22.65 %
108	2.21 %
111	14.50 %
112	0.38 %
113	15.59 %
118	2.56 %
121	3.81 %
122	18.99 %
129	5.80 %
130	13.51 %

The HFBL classes represented in the MIRC primarily range from moderate-loss bottoms (class 4, 5 and 6) to high-loss bottoms (classes 7 or 8). The distribution of HFBL classes summarized in Table F-7 indicates that approximately two-thirds of the MIRC is a high-loss bottom, with most of the remaining 40 percent a moderate-loss bottom.

Table F-7. Distribution of High-Frequency Bottom Loss Classes in MIRC

HFBL Class	Frequency of Occurrence
2	0.25 %
4	11.00 %
5	20.94 %
6	3.75 %
7	13.87 %
8	50.19 %

The logic for consolidating the environmental provinces focuses upon water depth, using the sound speed profile (in deep water) and the HFBL class (in shallow water) as secondary differentiating factors. The first consideration was to ensure that all five bathymetry provinces are represented. Then within each bathymetry province further partitioning of provinces proceeded as follows:

- The three shallowest bathymetry provinces are each represented by one environmental province. In each case, the bathymetry province is dominated by a single, high-loss bottom, so that the secondary differentiating environmental parameter is of no consequence.
- The 2,000-meter bathymetry province consists of two environmental provinces. The vast majority of this bathymetry province consists of high-loss bottoms making the SVP provinces making the more important secondary differentiating environmental parameter. The variance in the sound speed field, which is generally quite small, is represented by two SVP provinces.
- The 5,000-meter bathymetry province is far and away the most prevalent water depth in the MIRC. Although the environmental variability across this bathymetry province is relatively small, its sheer size relative to the other water depths warrants some partitioning to capture some of this variability. This is accomplished by subdividing this bathymetry province into four environmental provinces, one for each of the four most prevalent SVP provinces.

The resulting nine environmental provinces used in the MIRC acoustic modeling are described in Table F-8.

Table F-8: Distribution of Environmental Provinces in the MIRC Study Area

Environmental Province	Water Depth	SVP Province	HFBL Class	LFBL Province	Sediment Thickness	Frequency of Occurrence
1	200 m	122	8	– 98*	0.22 secs	0.23%
2	500 m	122	8	– 98*	0.16 secs	0.64%
3	1,000 m	122	8	62	0.2 secs	1.98%
4	2,000 m	122	8	62	0.19 secs	13.37%
5	2,000 m	111	8	62	0.19 secs	4.32%
6	5,000 m	98	5	13	0.18 secs	26.94%
7	5,000 m	122	8	13	0.1 secs	21.78%
8	5,000 m	111	4	43	0.39 secs	15.47%
9	5,000 m	113	4	43	0.32 secs	15.27%

* Negative province numbers indicate shallow water provinces

The percentages given in Table F-8 indicate the frequency of occurrence of each environmental province across the general operating area in the MIRC. The distributions of the environments within each of the SINKEX sub-areas are, by definition, limited to the two deepest bathymetry provinces as indicated in Table F-9.

Table F-9. Distribution of Environmental Provinces within SINKEX Sub-Areas

Environmental Province	SINKEX East	SINKEX South	SINKEX General
4	1.62%	0.00%	13.07%
5	0.00%	0.11%	2.98%
6	15.32%	99.89%	35.49%
7	83.06%	0.00%	13.68%
8	0.00%	0.00%	17.00%
9	0.00%	0.00%	17.78%

F.4 Impact Volumes and Impact Ranges

Many naval actions include the potential to injure or harass marine animals in the neighboring waters through noise emissions. The number of animals exposed to potential harassment in any such action is dictated by the propagation field and the characteristics of the noise source.

The impact volume associated with a particular activity is defined as the volume of water in which some acoustic metric exceeds a specified threshold. The product of this impact volume with a volumetric animal density yields the expected value of the number of animals exposed to that acoustic metric at a level that exceeds the threshold. The acoustic metric can either be an energy term (energy flux density, either in a limited frequency band or across the full band) or a pressure term (such as peak pressure or positive impulse). The thresholds associated with each of these metrics define the levels at which half of the animals exposed will experience some degree of harassment (ranging from behavioral change to mortality).

Impact volume is particularly relevant when trying to estimate the effect of repeated source emissions separated in either time or space. Impact range, which is defined as the maximum range at which a particular threshold is exceeded for a single source emission, defines the range to which marine mammal activity is monitored in order to meet mitigation requirements.

With the exception of explosive sources, the sole relevant measure of potential harm to the marine wildlife due to sonar activities is the accumulated (summed over all source emissions) energy flux density received by the animal over the duration of the activity. Harassment measures for explosive sources include energy flux density and pressure-related metrics (peak pressure and positive impulse).

Regardless of the type of source, estimating the number of animals that may be injured or otherwise harassed in a particular environment entails the following steps.

- Each source emission is modeled according to the particular operating mode of the sonar. The “effective” energy source level is computed by integrating over the bandwidth of the source, scaling by the pulse length, and adjusting for gains due to source directivity. The location of the source at the time of each emission must also be specified.
- For the relevant environmental acoustic parameters, transmission loss (TL) estimates are computed, sampling the water column over the appropriate depth and range intervals. TL data

are sampled at the typical depth(s) of the source and at the nominal center frequency of the source. If the source is relatively broadband, an average over several frequency samples is required.

- The accumulated energy within the waters that the source is "operating" is sampled over a volumetric grid. At each grid point, the received energy from each source emission is modeled as the effective energy source level reduced by the appropriate propagation loss from the location of the source at the time of the emission to that grid point and summed. For the peak pressure or positive impulse, the appropriate metric is similarly modeled for each emission. The maximum value of that metric, over all emissions, is stored at each grid point.
- The impact volume for a given threshold is estimated by summing the incremental volumes represented by each grid point for which the appropriate metric exceeds that threshold.
- Finally, the number of takes is estimated as the "product" (scalar or vector, depending on whether an animal density depth profile is available) of the impact volume and the animal densities.

This section describes in detail the process of computing impact volumes (that is, the first four steps described above). This discussion is presented in two parts: active sonars and explosive sources. The relevant assumptions associated with this approach and the limitations that are implied are also presented. The final step, computing the number of takes is discussed in subsection F.5.

F.4.1 Computing Impact Volumes for Active Sonars

This section provides a detailed description of the approach taken to compute impact volumes for active sonars. Included in this discussion are:

- Identification of the underwater propagation model used to compute transmission loss data, a listing of the source-related inputs to that model, and a description of the output parameters that are passed to the energy accumulation algorithm.
- Definitions of the parameters describing each sonar type.
- Description of the algorithms and sampling rates associated with the energy accumulation algorithm.

F.4.1.1 Transmission Loss Calculations

TL data are pre-computed for each of two seasons in each of the environmental provinces described in the previous subsection using the GRAB propagation loss model (Keenan, 2000). The TL output consists of a parametric description of each significant eigenray (or propagation path) from source to animal. The description of each eigenray includes the departure angle from the source (used to model the source vertical directivity later in this process), the propagation time from the source to the animal (used to make corrections to absorption loss for minor differences in frequency and to incorporate a surface-image interference correction at low frequencies), and the TL suffered along the eigenray path.

The eigenray data for a single GRAB model run are sampled at uniform increments in range out to a maximum range for a specific "animal" (or "target" in GRAB terminology) depth. Multiple GRAB runs are made to sample the animal depth dependence. The depth and range sampling parameters are summarized in Table F-10. Note that some of the low-power sources do not require TL data to large maximum ranges.

Table F-10: TL Depth and Range Sampling Parameters by Sonar Type

Sonar	Range Step	Maximum Range	Depth Sampling
MK-48	10 m	10 km	0 – 1 km in 5 m steps 1 km – Bottom in 10 m steps
AN/SQS-53C	10 m	200 km	0 – 1 km in 5 m steps 1 km – Bottom in 10 m steps
AN/AQS-22	10 m	10 km	0 – 1 km in 5 m steps 1 km – Bottom in 10 m steps
AN/ASQ-62	5 m	5 km	0 – 1 km in 5 m steps 1 km – Bottom in 10 m steps
AN/SQS-56	10 m	50 km	0 – 1 km in 5 m steps 1 km – Bottom in 10 m steps
BQQ-10	20 m	150 km	0 – 1 km in 5 m steps 1 km – Bottom in 10 m steps
AN/SQS-53C Kingfisher Mode	10 m	200 km	0 – 1 km in 5 m steps 1 km – Bottom in 10 m steps

In a few cases, most notably the AN/SQS-53C for thresholds below approximately 180 dB, TL data may be required by the energy summation algorithm at ranges greater than covered by the pre-computed GRAB data. In these cases, TL is extrapolated to the required range using a simple cylindrical spreading loss law in addition to the appropriate absorption loss. This extrapolation leads to a conservative (or under) estimate of TL at the greater ranges.

Although GRAB provides the option of including the effect of source directivity in its eigenray output, this capability is not exercised. By preserving data at the eigenray level, this allows source directivity to be applied later in the process and results in fewer TL calculations.

The other important feature that storing eigenray data supports is the ability to model the effects of surface-image interference that persist over range. However, this is primarily important at frequencies lower than those associated with the sonars considered in this subsection. A detailed description of the modeling of surface-image interference is presented in the subsection on explosive sources.

F.4.1.2 Energy Summation

The summation of EFD over multiple pings in a range-independent environment is a trivial exercise for the most part. A volumetric grid that covers the waters in and around the area of sonar operation is initialized. The source then begins its set of pings. For the first ping, the TL from the source to each grid point is determined (summing the appropriate eigenrays after they have been modified by the vertical beam pattern), the "effective" energy source level is reduced by that TL, and the result is added to the accumulated EFD at that grid point. After each grid point has been updated, the accumulated energy at grid points in each depth layer is compared to the specified threshold. If the accumulated energy exceeds that threshold, then the incremental volume represented by that grid point is added to the impact volume for that depth layer. Once all grid points have been processed, the resulting sum of the incremental volumes represents the impact volume for one ping.

The source is then moved along one of the axes in the horizontal plane by the specified ping separation range and the second ping is processed in a similar fashion. Again, once all grid points have been processed, the resulting sum of the incremental volumes represents the impact volume for two pings. This procedure continues until the maximum number of pings specified has been reached.

Defining the volumetric grid over which energy is accumulated is the trickiest aspect of this procedure. The volume must be large enough to contain all volumetric cells for which the accumulated energy is likely to exceed the threshold but not so large as to make the energy accumulation computationally unmanageable.

Determining the size of the volumetric grid begins with an iterative process to determine the lateral extent to be considered. Unless otherwise noted, throughout this process the source is treated as omni directional and the only animal depth that is considered is the TL target depth that is closest to the source depth (placing source and receiver at the same depth is generally an optimal TL geometry).

The first step is to determine the impact range (R_{MAX}) for a single ping. The impact range in this case is the maximum range at which the effective energy source level reduced by the TL is greater than the threshold. Next, the source is moved along a straight-line track and EFD is accumulated at a point that has a CPA range of R_{MAX} at the mid-point of the source track. That total EFD summed over all pings is then compared to the prescribed threshold. If it is greater than the threshold (which, for the first R_{MAX}, it must be) then R_{MAX} is increased by 10 percent, the accumulation process is repeated, and the total energy is again compared to the threshold. This continues until R_{MAX} grows large enough to ensure that the accumulated EFD at that lateral range is less than the threshold. The lateral range dimension of the volumetric grid is then set at twice R_{MAX}, with the grid centered along the source track. In the direction of advance for the source, the volumetric grid extends of the interval from [$-R_{MAX}$, 3 R_{MAX}] with the first source position located at zero in this dimension. Note that the source motion in this direction is limited to the interval [0, 2 R_{MAX}]. Once the source reaches 2 R_{MAX} in this direction, the incremental volume contributions have approximately reached their asymptotic limit and further pings add essentially the same amount. This geometry is demonstrated in Figure F-3.

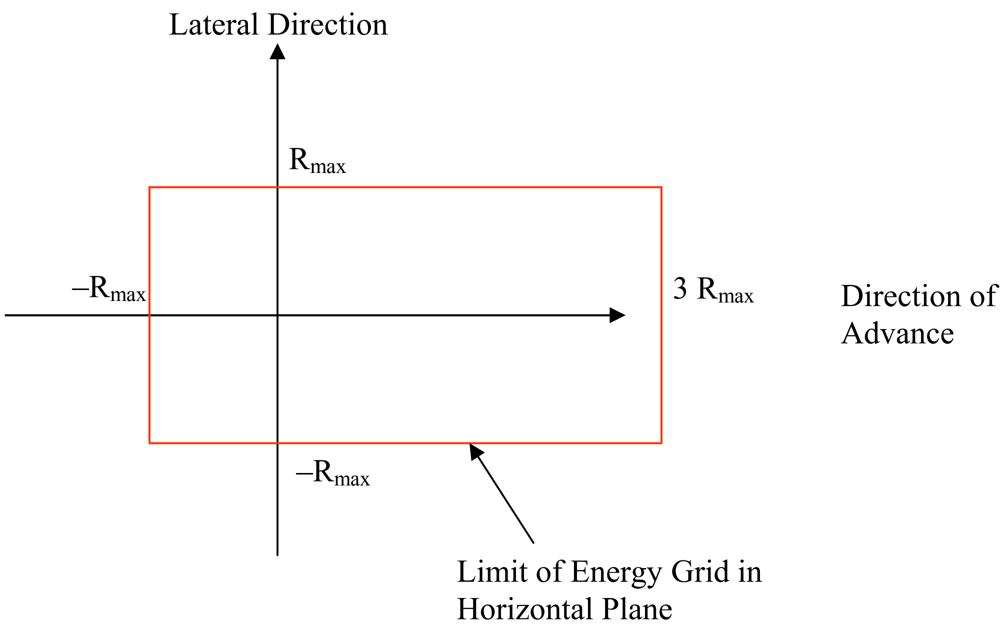


Figure F-3: Horizontal Plane of Volumetric Grid for Omni Directional Source

If the source is directive in the horizontal plane, then the lateral dimension of the grid may be reduced and the position of the source track adjusted accordingly. For example, if the main lobe of the horizontal source beam is limited to the starboard side of the source platform, then the port side of the track is reduced substantially as demonstrated in Figure F-4.

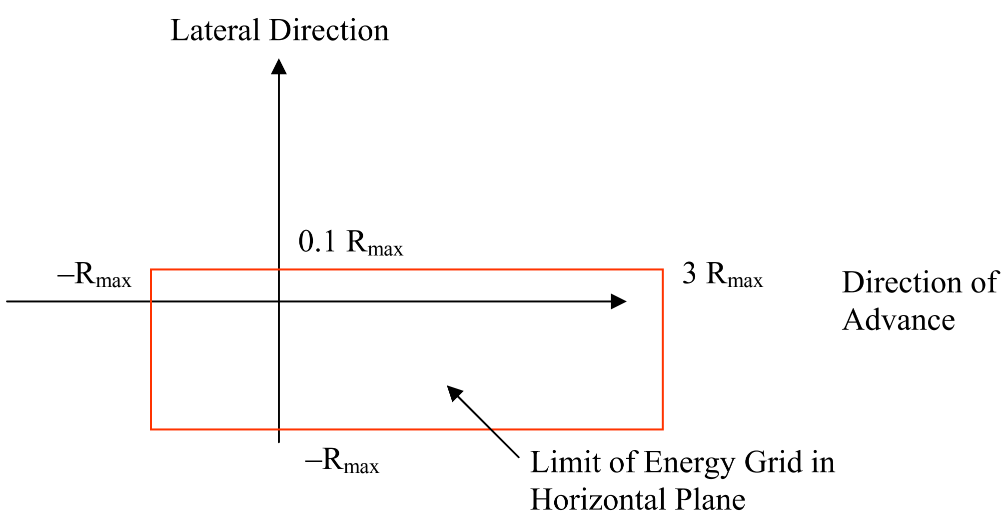


Figure F-4: Horizontal Plane of Volumetric Grid for Starboard Beam Source

Once the extent of the grid is established, the grid sampling can be defined. In both dimensions of the horizontal plane the sampling rate is approximately $R_{MAX}/100$. The round-off error associated with this sampling rate is roughly equivalent to the error in a numerical integration to determine the area of a circle with a radius of R_{MAX} with a partitioning rate of $R_{MAX}/100$ (approximately 1 percent). The depth-sampling rate of the grid is comparable to the sampling rates in the horizontal plane but discretized to match an actual TL sampling depth. The depth-sampling rate is also limited to no more than 10 meters to ensure that significant TL variability over depth is captured.

F.4.1.3 Impact Volume per Hour of Sonar Operation

The impact volume for a sonar moving relative to the animal population increases with each additional ping. The rate at which the impact volume increases varies with a number of parameters but eventually approaches some asymptotic limit. Beyond that point the increase in impact volume becomes essentially linear as depicted in Figure F-5.

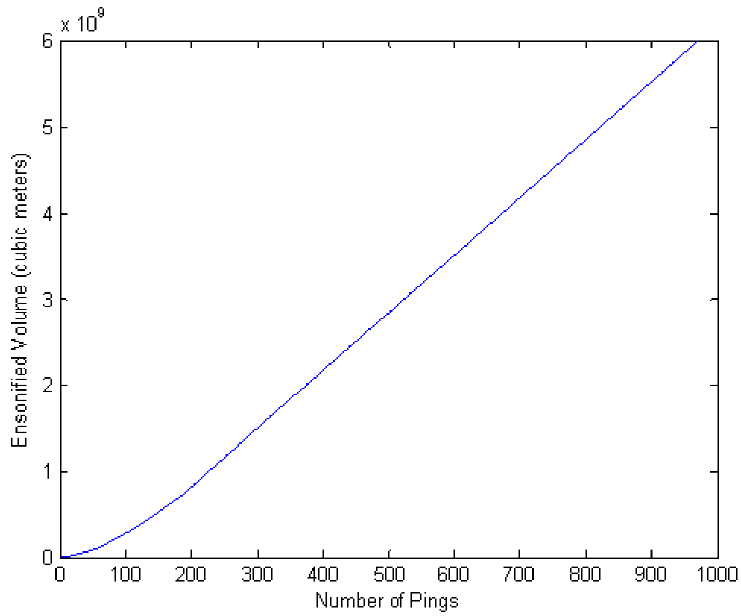


Figure F-5: 53C Impact Volume by Ping

The slope of the asymptotic limit of the impact volume in a given depth is the impact volume added per ping. This number multiplied by the number of pings in an hour gives the hourly impact volume for the given depth increment. Completing this calculation for all depths in a province, for a given source, gives the hourly impact volume vector, v_n, which contains the hourly impact volumes by depth for province n. Figure F-6 provides an example of an hourly impact volume vector for a particular environment.

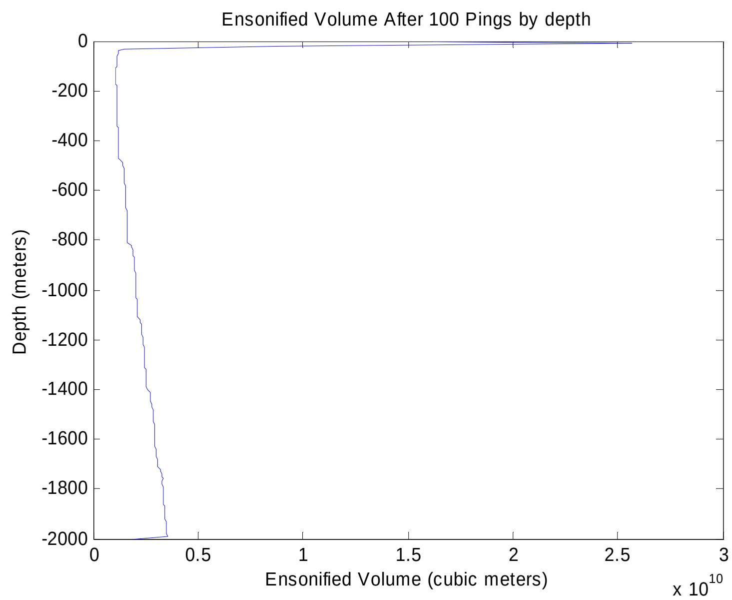


Figure F-6: Example of an Impact Volume Vector

F.4.2 Computing Impact Volumes for Explosive Sources

This section provides the details of the modeling of the explosive sources. This energy summation algorithm is similar to that used for sonars, only differing in details such as the sampling rates and source parameters. These differences are summarized in the following subsections. A more significant difference is that the explosive sources require the modeling of additional pressure metrics: (1) peak pressure, and (2) "modified" positive impulse. The modeling of each of these metrics is described in detail in the subsections of F.4.2.3.

F.4.2.1 Transmission Loss Calculations

Modeling impact volumes for explosive sources span requires the same type of TL data as needed for active sonars. However unlike active sonars, explosive ordnances and the EER source are broadband, contributing significant energy from tens of hertz to tens of kilohertz. To accommodate the broadband nature of these sources, TL data are sampled at seven frequencies from 10 Hz to 40 kHz, spaced every two octaves.

An important propagation consideration at low frequencies is the effect of surface-image interference. As either source or target approach the surface, pairs of paths that differ by a single surface reflection set up an interference pattern that ultimately causes the two paths to cancel each other when the source or target is at the surface. A fully coherent summation of the eigenrays produces such a result but also introduces extreme fluctuations that would have to be highly sampled in range and depth, and then smoothed to give meaningful results. An alternative approach is to implement what is sometimes called a semi-coherent summation. A semi-coherent sum attempts to capture significant effects of surface-image interference (namely the reduction of the field due to destructive interference of reflected paths as the source or target approach the surface) without having to deal with the more rapid fluctuations associated with a fully coherent sum. The semi-coherent sum is formed by a random phase addition of paths that have already been multiplied by the expression:

$$\sin^2 [4\pi f z_s z_a / (c^2 t)]$$

where f is the frequency, z_s is the source depth, z_a is the animal depth, c is the sound speed and t is the travel time from source to animal along the propagation path. For small arguments of the sine function this expression varies directly as the frequency and the two depths. It is this relationship that causes the propagation field to go to zero as the depths approach the surface or the frequency approaches zero

This surface-image interference must be applied across the entire bandwidth of the explosive source. The TL field is sampled at several representative frequencies. However, the image-interference correction given above varies substantially over that frequency spacing. To avoid possible under sampling, the image-interference correction is averaged over each frequency interval.

F.4.2.2 Source Parameters

Unlike active sonars, explosive sources are defined by only two parameters: (1) net explosive weight, and (2) source detonation depth. Values for these source parameters are defined earlier in subsection F.2.2.

The effective energy source level, which is treated as a de facto input for the other sonars, is instead modeled directly for EER and munitions. For both, the energy source level is comparable to the model used for other explosives (Arons (1954), Weston (1960), McGrath (1971), Urick (1983), Christian and Gaspin (1974)). The energy source level over a one-third octave band with a center frequency of f for a source with a net explosive weight of w pounds is given by:

$$ESL = 10 \log_{10} (0.26 f) + 10 \log_{10} (2 p_{max}^2 / [1/\theta^2 + 4 \pi f^2]) + 197 \text{ dB}$$

where the peak pressure for the shock wave at 1 meter is defined as

$$p_{max} = 21{,}600 (w^{1/3} / 3.28)^{1.13} \text{ psi} \qquad \text{(F-1)}$$

and the time constant is defined as:

$$\theta = [(0.058) (w^{1/3}) (3.28 / w^{1/3})^{0.22}] / 1{,}000 \text{ msec} \qquad \text{(F-2)}$$

In contrast to munitions that are modeled as omnidirectional sources, the EER source is a continuous line array that produces a directed source. The EER array consists of two explosive strips that are fired simultaneously from the center of the array. Each strip generates a beam pattern with the steer direction of the main lobe determined by the burn rate. The resulting response of the entire array is a bifurcated beam for frequencies above 200 Hz, while at lower frequencies the two beams tend to merge into one.

Since very short ranges are under consideration, the loss of directivity of the array needs to be accounted for in the near field of the array. This is accomplished by modeling the sound pressure level across the field as the coherent sum of contributions of infinitesimal sources along the array that are delayed according to the burn rate. For example, for frequency f the complex pressure contribution at a depth z and horizontal range x from an infinitesimal source located at a distance z' above the center of the array is

$$p(r,z) = e^{i\phi}$$

where

$$\phi = kr' + \alpha z', \text{ and}$$
$$\alpha = 2\pi f / c_b$$

with k the acoustic wave number, c_b the burn rate of the explosive ribbon, and r' the slant range from the infinitesimal source to the field point (x,z).

Beam patterns as function of vertical angle are then sampled at various ranges out to a maximum range that is approximately L^2 / □ where L is the array length and □ is the wavelength. This maximum range is a rule-of-thumb estimate for the end of the near field (Bartberger, 1965). Finally, commensurate with the resolution of the TL samples, these beam patterns are averaged over octave bands.

A couple of sample beam patterns are provided in Figure F-7 and Figure F-8. In both cases, the beam response is sampled at various ranges from the source array to demonstrate the variability across the near field. The 80-Hz family of beam patterns presented in Figure F-7 shows the rise of a single main lobe as range increases.

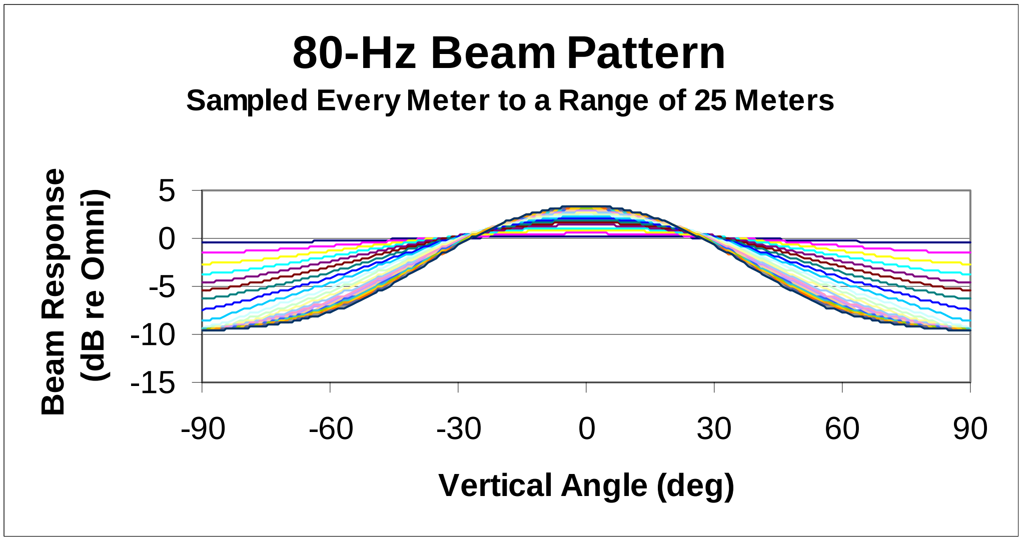


Figure F-7: 80-Hz Beam Patterns across Near Field of EER Source

On the other hand, the 1,250-Hz family of beam patterns depicted in Figure F-8 demonstrates the typical high-frequency bifurcated beam.

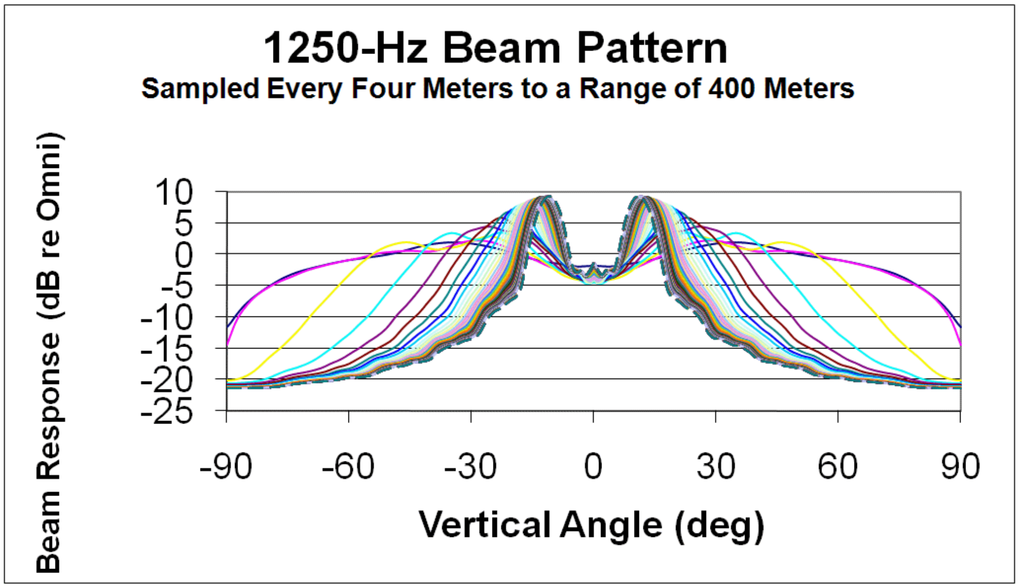


Figure F-8: 1,250-Hz Beam Patterns across Near Field of EER Source

F.4.2.3 Impact Volumes for Various Metrics

The impact of explosive sources on marine wildlife is measured by three different metrics, each with its own thresholds. The energy metric, peak one-third octave, is treated in similar fashion as the energy metric used for the active sonars, including the summation of energy if there are multiple source emissions. The other two, peak pressure and positive impulse, are not accumulated but rather the maximum levels are taken.

F.4.2.3.1 Peak One-Third Octave Energy Metric

The computation of impact volumes for the energy metric follows closely the approach taken to model the energy metric for the active sonars. The only significant difference is that EFD is sampled at several frequencies in one-third-octave bands and only the peak one-third-octave level is accumulated over time.

F.4.2.3.2 Peak Pressure Metric

The peak pressure metric is a simple, straightforward calculation at each range/animal depth combination. First, the transmission ratio, modified by the source level in a one-octave band and the vertical beam pattern, is averaged across frequency on an eigenray-by-eigenray basis. This averaged transmission ratio (normalized by the total broadband source level) is then compared across all eigenrays with the maximum designated as the peak arrival. Peak pressure at that range/animal depth combination is then simply the product of:

- The square root of the averaged transmission ratio of the peak arrival,
- The peak pressure at a range of one meter (given by equation F-1), and
- The similitude correction (given by $r^{-0.13}$, where r is the slant range along the eigenray estimated as tc with t the travel time along the dominant eigenray and c the nominal speed of sound).

If the peak pressure for a given grid point is greater than the specified threshold, then the incremental volume for the grid point is added to the impact volume for that depth layer.

F.4.2.3.3 "Modified" Positive Impulse Metric

The modeling of positive impulse follows the work of Goertner (Goertner, 1982). The Goertner model defines a "partial" impulse as

$$\int_{0}^{T_{min}} p(t)\, dt$$

where p(t) is the pressure wave from the explosive as a function of time t, defined so that p(t) = 0 for t < 0. This pressure wave is modeled as

$$p(t) = p_{max}\, e^{-t/\theta}$$

where p_{max} is the peak pressure at 1 meter (see, equation B-1), and θ is the time constant defined as

$$\theta = 0.058\ w^{1/3}\ (r/w^{1/3})^{0.22}\ \text{seconds}$$

with w the net explosive weight (pounds), and r the slant range between source and animal.

The upper limit of the "partial" impulse integral is

$$T_{min} = \min\ \{T_{cut}, T_{osc}\}$$

where T_{cut} is the time to cutoff and T_{osc} is a function of the animal lung oscillation period. When the upper limit is T_{cut}, the integral is the definition of positive impulse. When the upper limit is defined by T_{osc}, the integral is smaller than the positive impulse and thus is just a "partial" impulse. Switching the integral limit from T_{cut} to T_{osc} accounts for the diminished impact of the positive impulse upon the animals lungs that compress with increasing depth and leads to what is sometimes call a "modified" positive impulse metric.

The time to cutoff is modeled as the difference in travel time between the direct path and the surface-reflected path in an isospeed environment. At a range of r, the time to cutoff for a source depth z_s and an animal depth z_a is

$$T_{cut} = 1/c\ \{\ [r^2 + (z_a + z_s)^2]^{1/2} – [r^2 + (z_a – z_s)^2]^{1/2}\ \}$$

where c is the speed of sound.

The animal lung oscillation period is a function of animal mass M and depth z_a and is modeled as

$$T_{osc} = 1.17\ M^{1/3}\ (1 + z_a/33)^{-5/6}$$

where M is the animal mass (in kg) and z_a is the animal depth (in feet).

The modified positive impulse threshold is unique among the various injury and harassment metrics in that it is a function of depth and the animal weight. So instead of the user specifying the threshold, it is computed as $K\ (M/42)^{1/3}\ (1 + z_a\ /\ 33)^{1/2}$. The coefficient K depends upon the level of exposure. For the onset of slight lung injury, K is 19.7; for the onset of extensive lung hemorrhaging (1 percent mortality), K is 47.

Although the thresholds are a function of depth and animal weight, sometimes they are summarized as their value at the sea surface for a typical dolphin calf (with an average mass of 12.2 kg). For the onset of slight lung injury, the threshold at the surface is approximately 13 psi-msec; for the onset of extensive lung hemorrhaging (1 percent mortality), the threshold at the surface is approximately 31 psi-msec.

As with peak pressure, the "modified" positive impulse at each grid point is compared to the derived threshold. If the impulse is greater than that threshold, then the incremental volume for the grid point is added to the impact volume for that depth layer.

F.4.2.4 Impact Volume per Explosive Detonation

The detonations of explosive sources are generally widely spaced in time and/or space. This implies that the impact volume for multiple firings can be easily derived by scaling the impact volume for a single detonation. Thus the typical impact volume vector for an explosive source is presented on a per-detonation basis.

F.4.3 Impact Volume by Region

The MIRC is described by nine environmental provinces. The hourly impact volume vector for operations involving any particular source is a linear combination of the nine impact volume vectors with the weighting determined by the distribution of those nine environmental provinces within the range. Unique hourly impact volume vectors for winter and summer are calculated for each type of source and each metric/threshold combination.

F.5 Risk Function: Theoretical and Practical Implementation

This section discusses the recent addition of a risk function "threshold" to acoustic effects analysis procedure. This approach includes two parts, a new metric, and a function to map exposure level under the new metric to probability of harassment. What these two parts mean, how they affect exposure calculations, and how they are implemented are the objects of discussion.

Thresholds and Metrics

The term "thresholds" is broadly used to refer to both thresholds and metrics. The difference, and the distinct roles of each in effects analyses, will be the foundation for understanding the risk function approach, putting it in perspective, and showing that, conceptually, it is similar to past approaches.

Sound is a pressure wave, so at a certain point in space, sound is simply rapidly changing pressure. Pressure at a point is a function of time. Define p(t) as pressure (in micropascals) at a given point at time t (in seconds); this function is called a "time series." Figure F-9 gives the time series of the first "hallelujah" in Handel's Hallelujah Chorus.

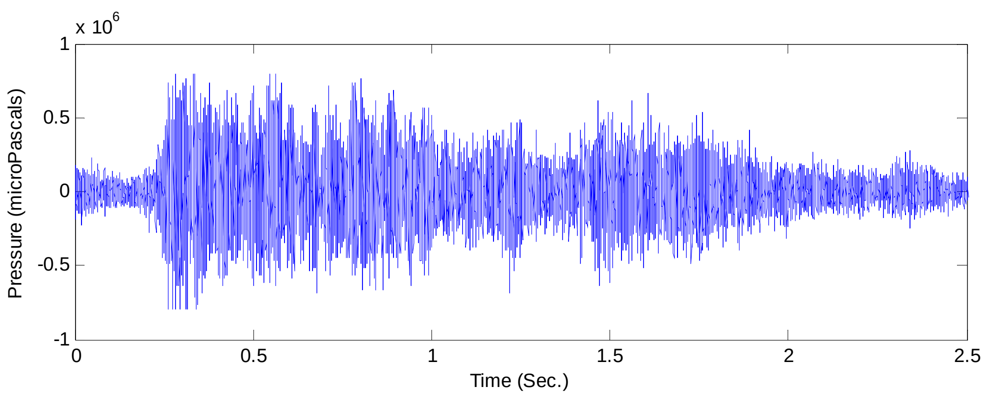


Figure F-9: Time Series

The time-series of a source can be different at different places. Therefore, sound, or pressure, is not only a function of time, but also of location. Let the function p(t), then be expanded to p(t;x,y,z) and denote the time series at point (x,y,z) in space. Thus, the series in Figure F-9 p(t) is for a given point (x,y,z). At a different point in space, it would be different.

Assume that the location of the source is (0,0,0) and this series is recorded at (0,10,-4). The time series above would be p(t;0,10,-4) for 0<t<2.5.

As in Figure F-9, pressure can be positive or negative, but acoustic power, which is proportional to the square of the pressure, is always positive, this makes integration meaningful. Figure F-10 is $p^2(t;0,10,-4)$.

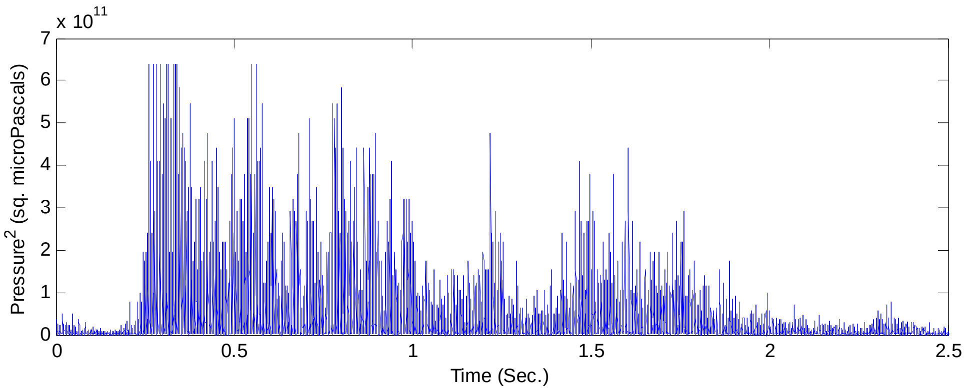


Figure F-10: Time Series Squared

The metric chosen to evaluate the sound field at the end of this first "hallelujah" determines how the time series is summarized from thousands of points, as in Figure F-9, to a single value for each point (x,y,z) in the space. The metric essentially "boils down" the four dimensional p(t,x,y,z) into a three dimensional function m(x,y,z) by dealing with time. There is more than one way to summarize the time component, so there is more than one metric.

Max Sound Pressure Level (SPL)

Because of the large dynamic range of the acoustic power, it is generally represented on a logarithmic scale using SPLs. SPL is actually the ratio of acoustic power density (power/unit area = $\frac{p^2}{Z}$ where Z = ρc is the acoustic impedance). This ratio is presented on a logarithmic scale relative to a reference pressure level, and is defined as:

$$SPL = 10\log_{10}(\frac{p^2}{p_{ref}^2}) = 20\log_{10}(abs\left(\frac{p}{p_{ref}}\right))$$

(Note that SPL is defined in dB re a reference pressure, even though it comes from a ratio of powers)

One way to characterize the power of the time series $p(t;x,y,z)$ with a single number over the 2.5 seconds is to only report the maximum SPL value of the function over time or,

$SPL_{\max} = \max\{10\log_{10}(p^2(t,x,y,z))\}$ (relative to a reference pressure of 1) for 0<t<2.5

The $SPL_{\max}$ for this snippet of the Hallelujah Chorus is:

$$10\log_{10}(6.4\times 10^{11}\,\mu Pa^2 / 1\mu Pa^2) = 118dB \text{ Re } 1\mu\text{Pa}$$

and occurs at 0.2606 seconds, as shown in Figure F-11.

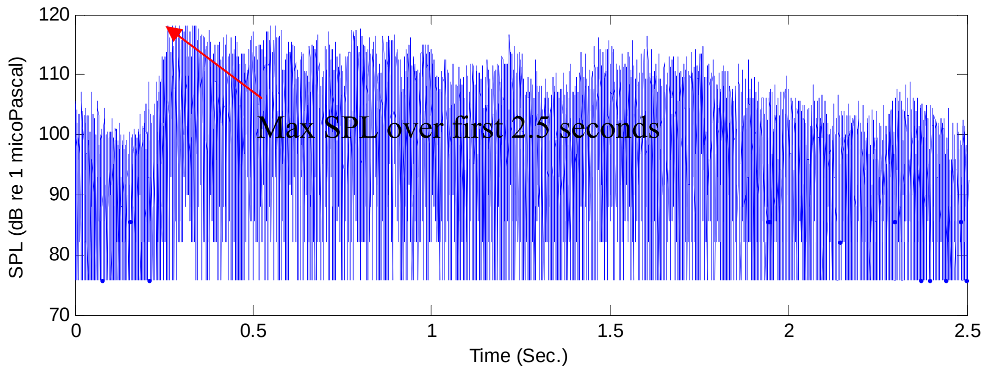


Figure F-11: Max SPL of Time Series Squared

Integration

SPL_{max} is not necessarily influenced by the duration of the sound (2.5 seconds in this case). Integrating the function over time gives the energy flux density, which does take this duration into account. A simple integration of $p^2(t;x,y,z)$ over t is common and is proportional to the energy flux density at (x,y,z). Because we will again be dealing in levels (logarithms of ratios), we neglect the impedance and simply measure the square of the pressure:

$$Energy = \int_0^T p^2(t,x,y,z)dt$$, where T is the maximum time of interest in this case 2.5.

The energy for this snippet of the Hallelujah Chorus is $8.47 \times 10^{10}\ \mu Pa^2 \cdot s$. This would more commonly be reported as an EL:

$$EL = 10\log_{10}\left(\frac{\int_0^T p^2(t,x,y,z)dt}{1.0\mu Pa^2 s}\right) = 109.3 \text{ dB Re } 1\mu\text{Pa}^2\text{s}$$

Energy is sometimes called "equal energy" because if p(t) is a constant function and the duration is doubled, the effect is the same as doubling the signal amplitude (y value). Thus, the duration and the signal have an "equal" influence on the energy metric.

Mathematically,

$$\int_0^{2T} p(t)^2\,dt = 2\int_0^T p(t)^2\,dt = \int_0^T 2p(t)^2\,dt$$

or a doubling in duration equals a doubling in energy equals a doubling in signal.

Sometimes, the integration metrics are referred to as having a "3 dB exchange rate" because if the duration is doubled, this integral increases by a factor of two, or 10log10(2)=3.01 dB. Thus, equal energy has "a 3 dB exchange rate."

After p(t) is determined (i.e., when the stimulus is over), propagation models can be used to determine p(t;x,y,z) for every point in the vicinity and for a given metric. Define

$$m_a(x, y, z, T) = \text{value of metric "a" at point (x,y,z) after time T}$$

So,

$$m_{energy}(x, y, z; T) = \int_0^T p(t)^2 \, dt$$

$$m_{\max\ SPL}(x, y, z; T) = \max(10 \log_{10}(p^2(t)))\ over\ [0, T]$$

Since modeling is concerned with the effects of an entire event, T is usually implicitly defined: a number that captures the duration of the event. This means that $m_a(x, y, z)$ is assumed to be measured over the duration of the received signal.

Three Dimensions versus Two Dimensions

To further reduce the calculation burden, it is possible to reduce the domain of $m_a(x, y, z)$ to two dimensions by defining $m_a(x, y) = \max\{m_a(x, y, z)\}$ over all z. This reduction is not used for this analysis, which is exclusively three-dimensional.

Threshold

For a given metric, a threshold is a function that gives the probability of exposure at every value of m_a. This threshold function will be defined as

$$D(m_a(x, y, z)) = \Pr(effect\ at\ m_a(x, y, z))$$

The domain of D is the range of $m_a(x, y, z)$, and its range is the number of thresholds.

An example of threshold functions is the Heavyside (or unit step) function, currently used to determine PTS and TTS in cetaceans. For PTS, the metric is $m_{energy}(x, y, z)$, defined above, and the threshold function is a Heavyside function with a discontinuity at 215 dB, shown in Figure F-12.

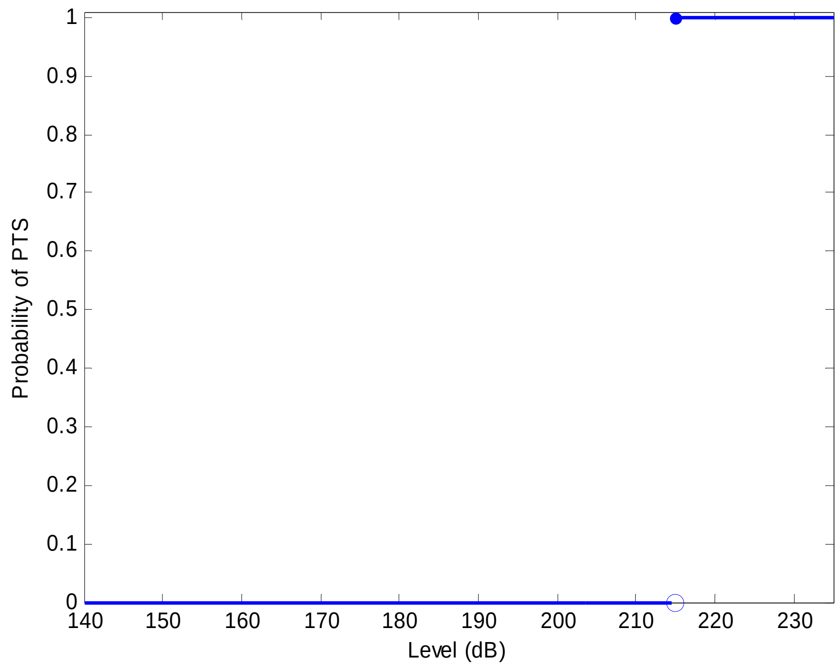


Figure F-12: PTS Heavyside Threshold Function

Mathematically, this D is defined as:

$$D(m_{energy}) = \begin{cases} 0 \;\; for \; m_{energy} < 215 \\ 1 \;\; for \; m_{energy} \geq 215 \end{cases}$$

Any function can be used for D, as long as its range is in [0,1]. The risk functions use normal Feller risk functions (defined below) instead of heavyside functions, and use the max SPL metric instead of the energy metric. While a heavyside function is specified by a single parameter, the discontinuity, a Feller function requires three parameters: the basement cutoff value, the level above the basement for 50 percent effect, and a steepness parameter. Mathematically, these Feller, "risk" functions, D, are defined as

$$D(m_{\max SPL}) = \begin{cases} \dfrac{1}{1+\left(\dfrac{K}{m_{\max SPL} - B}\right)^{A}} \;\; for \; m_{\max SPL} \geq B \\ 0 \;\; for \; m_{\max SPL} < B \end{cases}$$

where B=cutoff (or basement), K=the difference in level (dB) between the basement and the median (50 percent effect) harassment level, and A = the steepness factor. The risk function for odontocetes and pinnipeds uses the parameters:

B = 120 dB,
K = 45 dB, and
A = 10.

The risk function for mysticetes uses:

B = 120 dB,
K = 45 dB, and
A = 8.

Harbor porpoises are a special case. Though the metric for their behavioral harassment is also SPL, their risk function is a heavyside step function with a harassment threshold discontinuity (0 percent to 100 percent) at 120 dB. All other species use the continuous Feller CDF function for evaluating expected harassment.

Multiple Metrics and Thresholds

It is possible to have more than one metric, and more than one threshold in a given metric. For example, in this document, humpback whales have two metrics (energy and max SPL), and three thresholds (two for energy, one for max SPL). The energy thresholds are heavyside functions, as described above, with discontinuities at 215 and 195 for PTS and TTS respectively. The max SPL effect is calculated from the Feller risk function for odontocetes defined in the previous section.

Calculation of Expected Exposures

Determining the number of expected exposures for disturbance is the object of this analysis.

$$\text{Expected exposures in volume V} = \int_V \rho(V) D(m_a(V)) dV$$

For this analysis, $m_a = m_{\max SPL}$, so

$$\int_V \rho(V) D(m_a(V) dV = \int_{-\infty}^{\infty}\int_{-\infty}^{\infty}\int_{-\infty}^{\infty} \rho(x,y,z) D(m_{\max SPL}(x,y,z)) dxdydz$$

In this analysis, the densities are constant over the x/y plane, and the z dimension is always negative, so this reduces to

$$\int_{-\infty}^{0} \rho(z) \int_{-\infty}^{\infty}\int_{-\infty}^{\infty} D(m_{\max SPL}(x,y,z)) dxdydz$$

Numeric Implementation

Numeric integration of $\int_{-\infty}^{\infty} \rho(z) \int_{-\infty}^{\infty}\int_{-\infty}^{\infty} D(m_{\max SPL}(x,y,z)) dxdydz$ can be involved because, although the bounds are infinite, D is non-negative out to 141 dB, which, depending on the environmental specifics, can drive propagation loss calculations and their numerical integration out to more than 100 km.

The first step in the solution is to separate out the x/y-plane portion of the integral:

$$\text{Define f(z)} = \int_{-\infty}^{\infty}\int_{-\infty}^{\infty} D(m_{\max SPL}(x,y,z)) dxdy .$$

Calculation of this integral is the most involved and time consuming part of the calculation. Once it is complete,

$$\int_{-\infty}^{0} \rho(z) \int_{-\infty}^{\infty}\int_{-\infty}^{\infty} D(m_{\max SPL}(x,y,z)) dxdydz = \int_{-\infty}^{0} \rho(z) f(z) dz ,$$

which, when numerically integrated, is a simple dot product of two vectors.

Thus, the calculation of f(z) requires the majority of the computation resources for the numerical integration. The rest of this section presents a brief outline of the steps to calculate f(z) and preserve the results efficiently.

The concept of numerical integration is, instead of integrating over continuous functions, to sample the functions at small intervals and sum the samples to approximate the integral. The smaller the size of the intervals, the closer the approximation, but the longer the calculation, so a balance between accuracy and time is determined in the decision of step size. For this analysis, z is sampled in 5-meter steps to 1,000 meters in depth and 10-meter steps to 2,000 meters, which is the limit of animal depth in this analysis. The step size for x is 5 meters, and y is sampled with an interval that increases as the distance from the source increases. Mathematically,

$$z \in Z = \{0,5,...1000,1010,...,2000\}$$
$$x \in X = \{0,\pm 5,...,\pm 5k\}$$
$$y \in Y = \left\{0,\pm 5*(1.005)^0, \pm 5*\left[(1.005)^0 + (1.005)^1\right],...,\pm 5*\left[\sum_{i=0}^{j}(1.005)^i\right]\right\}$$

for integers k, j, which depend on the propagation distance for the source. For this analysis, k = 20,000 and j = 600.

With these steps, $f(z_0) = \int_{-\infty}^{\infty}\int_{-\infty}^{\infty} D(m_{\max SPL}(x,y,z_0))dxdy$ is approximated as

$$\sum_{z\in Y}\sum_{x\in X} D(m_{\max SPL}(x,y,z_0))\Delta x\Delta y$$

where X,Y are defined as above.

This calculation must be repeated for each $z_0 \in Z$, to build the discrete function f(z).

With the calculation of f(z) complete, the integral of its product with $\rho(z)$ must be calculated to complete evaluation of

$$\int_{-\infty}^{\infty}\rho(z)\int_{-\infty}^{\infty}\int_{-\infty}^{\infty} D(m_{\max SPL}(x,y,z))dxdydz = \int_{-\infty}^{0}\rho(z)f(z)dz$$

Since f(z) is discrete, and $\rho(z)$ can be readily made discrete, $\int_{-\infty}^{0}\rho(z)f(z)dz$ is approximated numerically as $\sum_{z\in Z}\rho(z)f(z)$, a dot product.

Preserving Calculations for Future Use

Calculating f(z) is the most time-consuming part of the numerical integration, but the most time-consuming portion of the entire process is calculating $m_{\max SPL}(x,y,z)$ over the area range required for the minimum cutoff value (141 dB). The calculations usually require propagation estimates out to over 100 km, and those estimates, with the beam pattern, are used to construct a sound field that extends 200 km x 200 km (40,000 sq km), with a calculation at the steps for every value of X and Y, defined above. This is repeated for each depth, to a maximum of 2,000 meters.

Saving the entire $m_{\max SPL}$ for each z is unrealistic, requiring great amounts of time and disk space. Instead, the different levels in the range of $m_{\max SPL}$ are sorted into 0.5 dB wide bins; the volume of water at each bin level is taken from $m_{\max SPL}$, and associated with its bin. Saving this, the amount of water ensonified at each level, at 0.5 dB resolution, preserves the ensonification information without using the space and time required to save $m_{\max SPL}$ itself. Practically, this is a histogram of occurrence of level at each depth, with 0.5 dB bins. Mathematically, this is simply defining the discrete functions $V_z(L)$, where $L = \{.5a\}$ for every positive integer a, for all $z \in Z$. These functions, or histograms, are saved for future work. The information lost by saving only the histograms is *where* in space the different levels occur, although *how often* they occur is saved. But the thresholds (risk function curves) are purely a function of level, not location, so this information is sufficient to calculate f(z).

Applying the risk function to the histograms is a dot product:

$$\sum_{\ell \in L_1} D(\ell) V_{z_0}(\ell) \approx \int_{-\infty}^{\infty}\int_{-\infty}^{\infty} D(m_{\max SPL}(x, y, z_0))dxdy$$

So, once the histograms are saved, neither $m_{\max SPL}(x, y, z)$ nor f(z) must be recalculated to generate $\int_{-\infty}^{0} \rho(z) \int_{-\infty}^{\infty}\int_{-\infty}^{\infty} D(m_{\max SPL}(x, y, z))dxdydz$ for a new threshold function.

For the interested reader, the following section includes an in-depth discussion of the method, software, and other details of the f(z) calculation.

Software Detail

The risk function metric uses the cumulative normal probability distribution to determine the probability that an animal is affected by a given SPL. The probability distribution is defined by a low-level cutoff level (below which the species is not affected), a 50 percent effect level, and a steepness factor. The acoustic quantity of interest is the maximum SPL experienced over multiple pings in a range-independent environment. The procedure for calculating the impact volume at a given depth is relatively simple. In brief, given the SPL of the source and the TL curve, the received SPL is calculated on a volumetric grid. For a given depth, volume associated with each SPL interval is calculated. Then, this volume is multiplied by the probability that an animal will be affected by that SPL. This gives the impact volume for that depth, that can be multiplied by the animal densities at that depth, to obtain the number of animals affected at that depth. The process repeats for each depth to construct the impact volume as a function of depth.

The case of a single emission of sonar energy, one ping, illustrates the computational process in more detail. First, the sound pressure levels are segregated into a sequence of bins that cover the range encountered in the area. The SPL are used to define a volumetric grid of the local sound field. The impact volume for each depth is calculated as follows: for each depth in the volumetric grid, the SPL at each x/y plane grid point is calculated using the SPL of the source, the TL curve, the horizontal beam pattern of the source, and the vertical beam patterns of the source. The sound pressure levels in this grid become the bins in the volume histogram. Figure F-13 shows a volume histogram for a low-power sonar. Level bins are 0.5 dB in width and the depth is 50 meters in an environment with water depth of 100 meters. The oscillatory structure at very low levels is due the flattening of the TL curve at long distances from the source, which magnifies the fluctuations of the TL as a function of range. The "expected" impact volume for a given level at a given depth is calculated by multiplying the volume in each level bin by the risk function probability function at that level. Total expected impact volume for a given depth is the sum of these "expected" volumes. Figure F-14 is an example of the impact volume as a function of depth at a water depth of 100 meters.

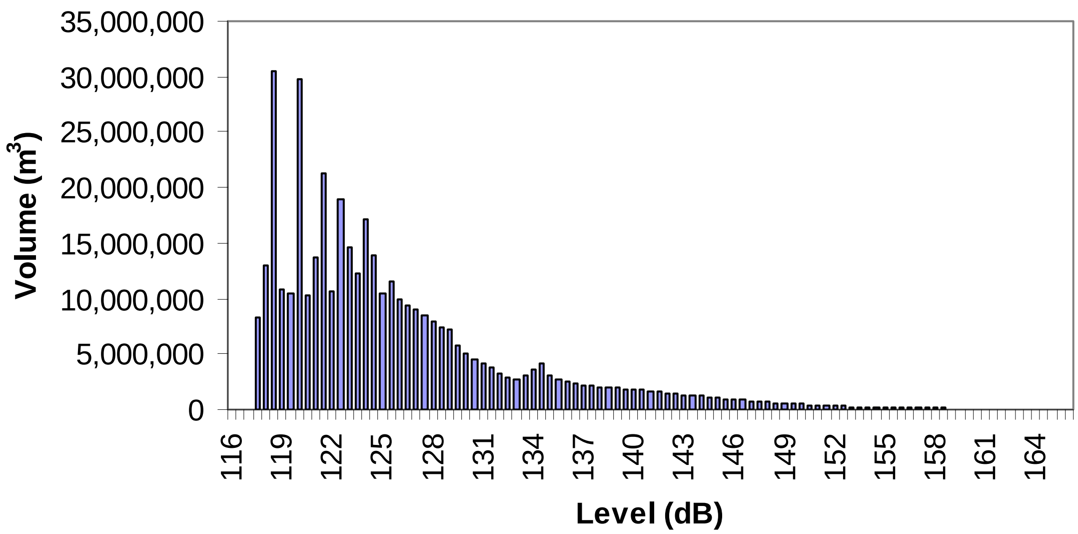


Figure F-13: Example of a Volume Histogram

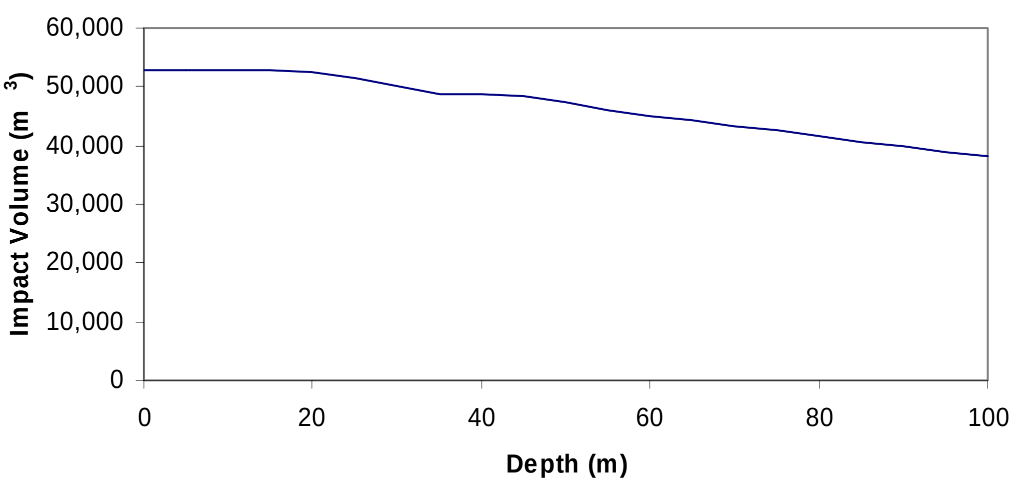


Figure F-14: Example of the Dependence of Impact Volume on Depth

The volumetric grid covers the waters in and around the area of sonar operation. The grid for this analysis has a uniform spacing of 5 meters in the x-coordinate and a slowly expanding spacing in the y-coordinate that starts with 5 meters spacing at the origin. The growth of the grid size along the y-axis is a geometric series. Each successive grid size is obtained from the previous by multiplying it by 1+Ry, where Ry is the y-axis growth factor. The n^{th} grid size is related to the first grid size by multiplying by $(1+Ry)^{(n-1)}$. For an initial grid size of 5 meters and a growth factor of 0.005, the 100^{th} grid increment is 8.19 meters. The constant spacing in the x-coordinate allows greater accuracy as the source moves along the x-axis. The slowly increasing spacing in y reduces computation time, while maintaining accuracy, by taking advantage of the fact that TL changes more slowly at longer distances from the source. The x-and y-coordinates extend from –Rmax to +Rmax, where Rmax is the maximum range used in the TL calculations. The z direction uses a uniform spacing of 5 meters down to 1,000 meters and 10 meters from 1,000 to 2,000 meters. This is the same depth mesh used for the effective energy metric as described above. The depth mesh does not extend below 2,000 meters, on the assumption that animals of interest are not found below this depth.

The next three figures indicate how the accuracy of the calculation of impact volume depends on the parameters used to generate the mesh in the horizontal plane. Figure F-15 shows the relative change of impact volume for one ping as a function of the grid size used for the x-axis. The y-axis grid size is fixed at 5m and the y-axis growth factor is 0, i.e., uniform spacing. The impact volume for a 5 meters grid size is the reference. For grid sizes between 2.5 and 7.5 meters, the change is less than 0.1 percent. A grid size of 5 meters for the x-axis is used in the calculations. Figure F-16 shows the relative change of impact volume for one ping as a function of the grid size used for the y-axis. The x-axis grid size is fixed at 5 meters and the y-axis growth factor is 0. The impact volume for a 5-meter grid size is the reference. This figure is very similar to that for the x-axis grid size. For grid sizes between 2.5 and 7.5 meters, the change is less than 0.1 percent. A grid size of 5 meters is used for the y-axis in our calculations. Figure F-17 shows the relative change of impact volume for one ping as a function of the y-axis growth factor. The x-axis grid size is fixed at 5 meters and the initial y-axis grid size is 5 meters. The impact volume for a growth factor of 0 is the reference. For growth factors from 0 to 0.01, the change is less than 0.1 percent. A growth factor of 0.005 is used in the calculations.

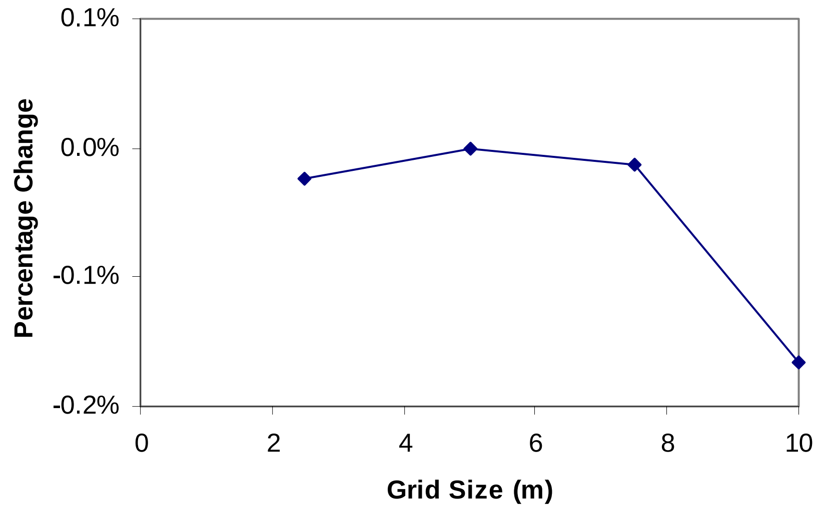


Figure F-15: Change of Impact Volume as a Function of X-Axis Grid Size.

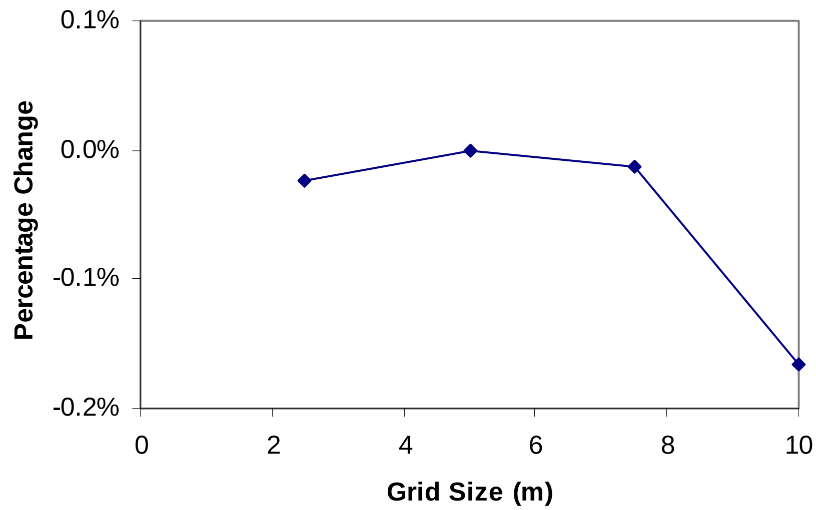


Figure F-16: Change of Impact Volume as a Function of Y-Axis Grid Size

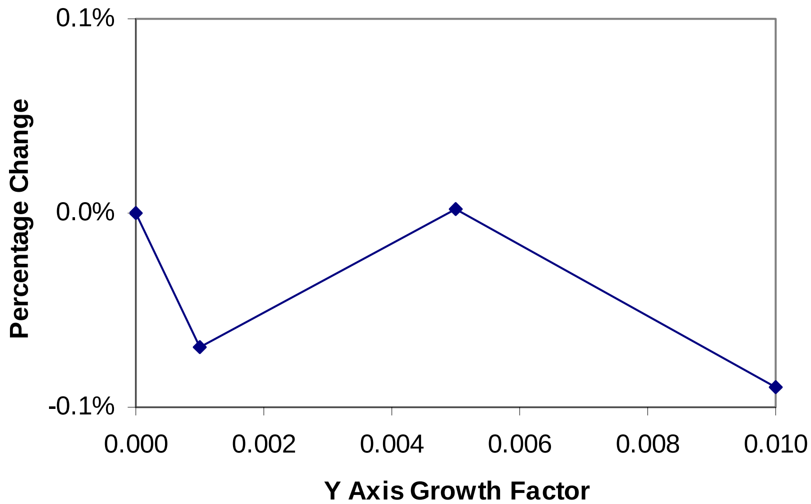


Figure F-17: Change of Impact Volume as a Function of Y-Axis Growth Factor

Another factor influencing the accuracy of the calculation of impact volumes is the size of the bins used for SPL. The SPL bins extend from 100 dB (far lower than required) up to 300 dB (much higher than that expected for any sonar system). Figure F-18 shows the relative change of impact volume for one ping as a function of the bin width. The x-axis grid size is fixed at 5 meters the initial y-axis grid size is 5 meters, and the y-axis growth factor is 0.005. The impact volume for a bin size of 0.5 dB is the reference. For bin widths from 0.25 dB to 1.00 dB, the change is about 0.1 percent. A bin width of 0.5 is used in our calculations.

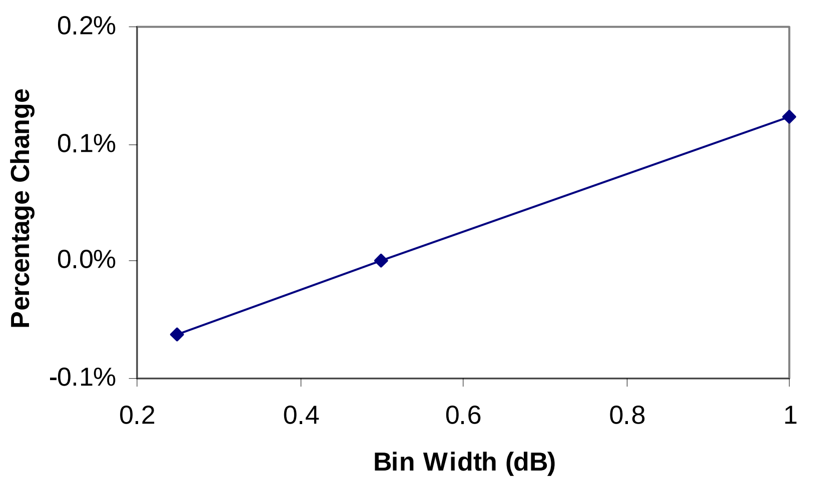


Figure F-18: Change of Impact Volume as a Function of Bin Width

Two other issues for discussion are the maximum range (Rmax) and the spacing in range and depth used for calculating TL. The TL generated for the energy accumulation metric is used for risk function analysis. The same sampling in range and depth is adequate for this metric because it requires a less demanding computation (i.e., maximum value instead of accumulated energy). Using the same value of Rmax needs some discussion since it is not clear that the same value can be used for both metrics. Rmax was set so that the TL at Rmax is more than needed to reach the energy accumulation threshold of 173 dB for 1,000 pings. Since energy is accumulated, the same TL can be used for one ping with the source level increased by 30 dB (10 $\log_{10}$(1,000)). Reducing the source level by 30 dB, to get back to its original value, permits the handling of a sound pressure level threshold down to 143 dB, comparable to the minimum required. Hence, the TL calculated to support energy accumulation for 1,000 pings will also support calculation of impact volumes for the risk function metric.

The process of obtaining the maximum SPL at each grid point in the volumetric grid is straightforward. The active sonar starts at the origin and moves at constant speed along the positive x-axis emitting a burst of energy, a ping, at regularly spaced intervals. For each ping, the distance and horizontal angle connecting the sonar to each grid point is computed. Calculating the TL from the source to a grid point has several steps. The TL is made up of the sum of many eigenrays connecting the source to the grid point. The beam pattern of the source is applied to the eigenrays based on the angle at which they leave the source. After summing the vertically beamformed eigenrays on the range mesh used for the TL calculation, the vertically beamformed TL for the distance from the sonar to the grid point is derived by interpolation. Next, the horizontal beam pattern of the source is applied using the horizontal angle connecting the sonar to the grid point. To avoid problems in extrapolating TL, only grid points with distances less than R_{max} are used. To obtain the SPL at a grid point, the SPL of the source is reduced by that TL. For the first ping, the volumetric grid is populated by the calculated SPL at each grid point. For the second ping and subsequent pings, the source location increments along the x-axis by the spacing between pings and the SPL for each grid point is again calculated for the new source location. Since the risk function metric uses the maximum of the SPLs at each grid point, the newly calculated SPL at each grid point is compared to the SPL stored in the grid. If the new level is larger than the stored level, the value at that grid point is replaced by the new SPL.

For each bin, a volume is determined by summing the ensonified volumes with a maximum SPL in the bin's interval. This forms the volume histogram shown in Figure F-13. Multiplying by the risk function probability function for the level at the center of a bin gives the impact volume for that bin. The result can be seen in Figure F-14, which is an example of the impact volume as a function of depth.

The impact volume for a sonar moving relative to the animal population increases with each additional ping. The rate at which the impact volume increases for the risk function metric is essentially linear with the number of pings. Figure F-19 shows the dependence of impact volume on the number of pings. The function is linear; the slope of the line at a given depth is the impact volume added per ping. This number multiplied by the number of pings in an hour gives the hourly impact volume for the given depth increment. Completing this calculation for all depths in a province, for a given source, gives the hourly impact volume vector which contains the hourly impact volumes by depth for a province. Figure F-20 provides an example of an hourly impact volume vector for a particular environment. Given the speed of the sonar platform, the hourly impact volume vector could be displayed as the impact volume vector per kilometer of track.

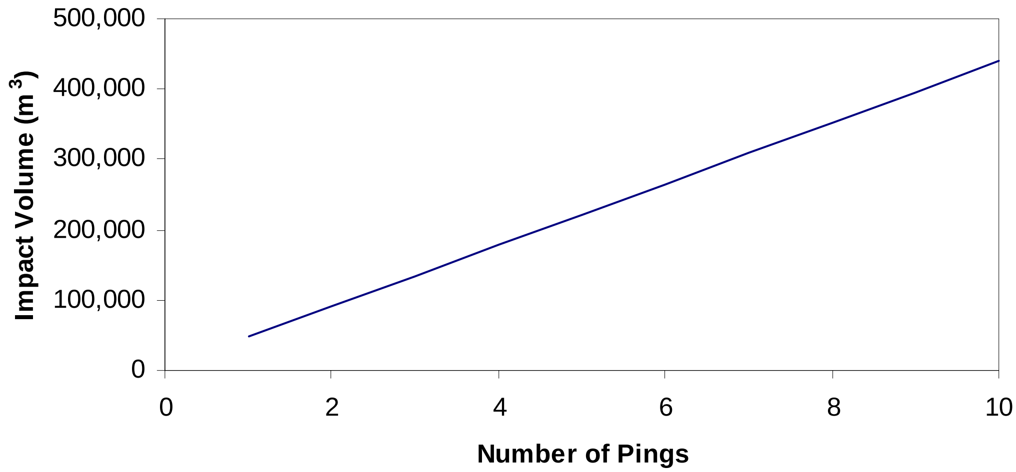


Figure F-19: Dependence of Impact Volume on the Number of Pings

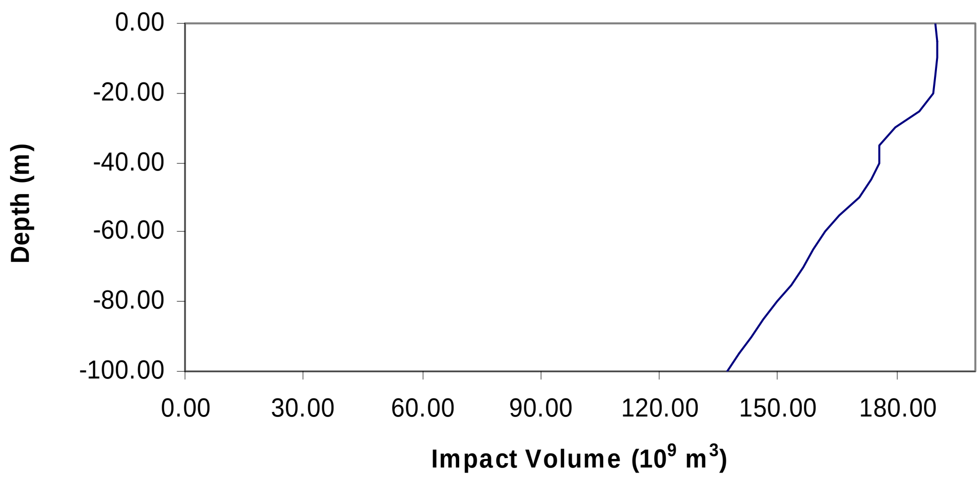


Figure F-20: Example of an Hourly Impact Volume Vector

F.6 Harassments

This section defines the animal densities and their depth distributions for the MIRC. This is followed by a series of tables providing harassment estimates per unit of operation for each source type (active sonars and explosives).

F.6.1 Animal densities

Densities are usually reported by marine biologists as animals per square kilometer, which is an area metric. This gives an estimate of the number of animals below the surface in a certain area, but does not provide any information about their distribution in depth. The impact volume vector (see subsection A.4.3) specifies the volume of water ensonified above the specified threshold in each depth interval. A corresponding animal density for each of those depth intervals is required to compute the expected value of the number of exposures. The two-dimensional area densities do not contain this information, so three-dimensional densities must be constructed by using animal depth distributions to extrapolate the density at each depth. The required depth distributions are presented in the biology subsection.

F.6.2 Exposure Estimates

The following sperm whale example demonstrates the methodology used to create a three-dimensional density by merging the area densities with the depth distributions. The sperm whale surface density is 0.0028 whales per square kilometer. From the depth distribution report, "depth distribution for sperm whales based on information in the Amano paper is: 19 percent in 0-2 m, 10 percent in 2-200 m, 11 percent in 201-400 m, 11 percent in 401-600 m, 11 percent in 601-800 m and 38 percent in >800 m." So the sperm whale density at 0-2 m is 0.0028*0.19/0.002 = 0.266 per cubic km, at 2-200 m is 0.0028*0.10/0.198 = 0.001414 per cubic km, and so forth.

In general, the impact volume vector samples depth in finer detail than given by the depth distribution data. When this is the case, the densities are apportioned uniformly over the appropriate intervals. For example, suppose the impact volume vector provides volumes for the intervals 0-2 meters, 2-10 meters, and 10-50 meters. Then for the depth-distributed densities discussed in the preceding paragraph,

- 0.266 whales per cubic km is used for 0-2 meters,
- 0.001414 whales per cubic km is used for the 2-10 meters, and
- 0.001414 whales per square km is used for the 10-50 meters.

Once depth-varying, three-dimensional densities are specified for each species type, with the same depth intervals and the ensonified volume vector, the density calculations are finished. The expected number of ensonified animals within each depth interval is the ensonified volume at that interval multiplied by the volume density at that interval and this can be obtained as the dot product of the ensonified volume and animal density vectors.

Since the ensonified volume vector is the ensonified volume per unit operation (i.e., per hour, per sonobuoy, etc), the final harassment count for each animal is the unit operation harassment count multiplied by the number of units (hours, sonobuoys, etc). The number of unit operations for each source are provided in Table F-1.

F.6.3 Post Acoustic Modeling Analysis

The acoustic modeling results include additional analysis to account for land mass, multiple ships, and number of animals that could be exposed. Specifically, post modeling analysis is designed to consider:

- Acoustic footprints for sonar sources must account for land masses.
- Acoustic footprints for sonar sources should not be added independently, which would result in overlap with other sonar systems used during the same active sonar activity. As a consequence, the area of the total acoustic footprint would be larger than the actual acoustic footprint when multiple ships are operating together.
- Acoustic modeling should account for the maximum number of individuals of a species that could potentially be exposed to sonar within the course of 1 day or a discreet continuous sonar event if less than 24 hours.

When modeling the effect of sound projectors in the water, the ideal task presents modelers with complete *a priori* knowledge of the location of the source(s) and transmission patterns during the times of interest.

In these cases, calculation inputs include the details of source path, proximity of shoreline, high-resolution density estimates, and other details of the scenario. However, in the MIRC, there are sound-producing events for which the source locations, and transmission patterns are unknown, but still require analysis to predict effects. For these cases, a more general modeling approach is required: "We will be operating somewhere in this large area for X minutes. What are the potential effects on average?"

Modeling these general scenarios requires a statistical approach to incorporate the scenario nuances into harassment calculations. For example, one may ask: "If an animal receives 130 decibel (dB) SPL when the source passes at closest point of approach (CPA) on Tuesday morning, how do we know it doesn't receive a higher level on Tuesday afternoon?" This question cannot be answered without knowing the path of the source (and several other facts). Because the path of the source is unknown, the number of an individual's re-exposures cannot be calculated directly. But it can, on average, be accounted for by making appropriate assumptions.

Table F-11 lists unknowns created by uncertainty about the specifics of a future proposed action, the portion of the calculation to which they are relevant, and the assumption that allows the effect to be computed without the detailed information.

The following sections discuss three topics that require action details, and describe how the modeling calculations used the general knowledge and assumptions to overcome the future-action uncertainty with respect to re-exposure of animals, land shadow, and the effect of multiple-ship training events.

Table F-11: Unknowns and Assumptions

Unknowns	Relevance	Assumption
Path of ship (esp. with respect to animals)	Ambiguity of multiple exposures, Local population: upper bound of harassments	Most conservative case: ships are everywhere within Sonar Operating Area
Source(s) locations	Ambiguity of multiple exposures, land shadow	Equal distribution of action in each modeling area
Direction of sonar transmission	Land shadow	Equal probability of pointing any direction
Number of ships	Effect of multiple ships	Average number of ships per training event
Distance between ships	Effect of multiple ships	Average distance between ships

F.6.3.1 Multiple Exposures in General Modeling Scenario

Consider the following hypothetical scenario. A box is painted on the surface of a well-studied ocean environment with well-known sound propagation characteristics. A sonar source and 100 whales are inserted into that box and a curtain is drawn. What will happen? The details of what will happen behind the curtain are unknown, but the existing knowledge, and general assumptions, can allow for a calculation of average effects.

For the first period of time, the source is traveling in a straight line and pinging at a given rate. In this time, it is known how many animals, on average, receive their max SPLs from each ping. As long as the source travels in a straight line, this calculation is valid. However, after an undetermined amount of time, the source will change course to a new and unknown heading.

If the source changes direction 180 degrees and travels back through the same swath of water, all the animals the source passes at closest point of approach (CPA) before the next course change have already been exposed to what will be their maximum SPL, so the population is not “fresh.” If the direction does not change, only new animals will receive what will be their maximum SPL from that source (though most have received sound from it), so the population is completely “fresh.” Most source headings lead to a population of a mixed “freshness,” varying by course direction. Since the route and position of the source over time are unknown, the freshness of the population at CPA with the source is unknown. This ambiguity continues through the remainder of the exercise.

What is known? The source and, in general, the animals remain in the vicinity of the OPAREA. Thus, if the farthest range to a possible effect from the source is X kilometers (km), no animals farther than X km outside of the OPAREA can be harassed. The intersection of this area with a given animal's habitat multiplied by the density of that animal in its habitat represents the maximum number of animals that can be harassed by activity in that OPAREA, which shall be defined as “the local population.” Two details: first, this maximum should be adjusted down if a risk function is being used, because not 100% of animals within X km of the OPAREA border will be harassed. Second, it should be adjusted up to account for animal motion in and out of the area.

The ambiguity of population freshness throughout the training event means that multiple exposures cannot be calculated for any individual animal. It must be dealt with generally at the population level.

Solution to the Ambiguity of Multiple Exposures in the General Modeling Scenario

At any given time, each member of the population has received a maximum SPL (possibly zero) that indicates the probability of harassment during the training event. This probability indicates the contribution of that individual to the expected value of the number of harassments. For example, if an animal receives a level that indicates 50 percent probability of harassment, it contributes 0.5 to the sum of the expected number of harassments. If it is passed later with a higher level that indicates a 70 percent chance of harassment, its contribution increases to 0.7. If two animals receive a level that indicates 50 percent probability of harassment, they together contribute 1 to the sum of the expected number of harassments. That is, we statistically expect exactly one of them to be harassed. Let the expected value of harassments at a given time be defined as “the harassed population” and the difference between the local population (as defined above) and the harassed population be defined as “the unharassed population.” As the training event progresses, the harassed population will never decrease and the unharassed population will never increase.

The unharassed population represents the number of animals statistically “available” for harassment. Since we do not know where the source is, or where these animals are, we assume an average (uniform) distribution of the unharassed population over the area of interest. The densities of unharassed animals are lower than the total population density because some animals in the local population are in the harassed population.

Density relates linearly to expected harassments. If action A, in an area with a density of 2 animals per square kilometer (km^2) produces 100 expected harassments, then action A in an area with 1 animal per km^2 produces 50 expected harassments. The modeling produces the number of expected harassments per ping starting with 100 percent of the population unharassed. The next ping will produce slightly fewer harassments because the pool of unharassed animals is slightly less.

For example, consider the case where 1 animal is harassed per ping when the local population is 100, 100 percent of which are initially unharassed. After the first ping, 99 animals are unharassed, so the number of animals harassed during the second ping are

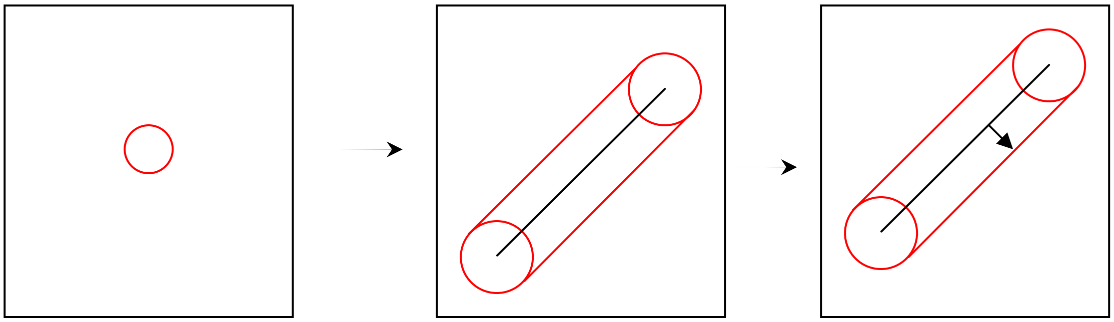
$$10\left(\frac{99}{100}\right) = 1(.99) = 0.99 \text{ animals}$$

and so on for the subsequent pings.

Mathematics

A closed form function for this process can be derived as follows.

Define $H =$ number of animals harassed per ping with 100 percent unharassed population. H is calculated by determining the expected harassment for a source moving in a straight line for the duration of the exercise and dividing by the number of pings in the exercise (Figure F-21).



$$\mathrm{H} = \int\int\int \rho(z) D(L(x,y,z))dxdydz \,/\mathrm{N\_pings}$$

Figure F-21: Process of Calculating H

The total unharassed population is then calculated by iteration. Each ping affects the unharassed population left after all previous pings:

Define P_n = unharassed population after ping n

$$P_0 = \text{local population}$$
$$P_1 = P_0 - H$$
$$P_2 = P_1 - H\left(\frac{P_1}{P_0}\right)$$
...
$$P_n = P_{n-1} - H\left(\frac{P_{n-1}}{P_0}\right)$$

Therefore,

$$P_n = P_{n-1}\left(1-\left(\frac{H}{P_0}\right)\right) = P_{n-2}\left(1-\left(\frac{H}{P_0}\right)\right)^2 = \ldots = P_0\left(1-\left(\frac{H}{P_0}\right)\right)^n$$

Thus, the total number of harassments depends on the per-ping harassment rate in an unharassed population, the local population size, and the number of operation hours.

Local Population: Upper Bound on Harassments

As discussed above, Navy planners have confined periods of sonar use to training areas. The size of the harassed population of animals for an action depends on animal re-exposure, so uncertainty about the precise source path creates variability in the "harassable" population. Confinement of sonar use to a sonar training area allows modelers to compute an upper bound, or worst case, for the number of harassments with respect to location uncertainty. This is done by assuming that every animal which enters the training area at any time in the exercise (and also many outside) is "harassable" and creates an upper bound on the number of harassments for the exercise. Since this is equivalent to assuming that there are sonars transmitting simultaneously from each point in the confined area throughout the action length, this greatly overestimates the take from an exercise.

NMFS has defined a 24-hour "refresh rate," or amount of time in which an individual can be harassed no more than once. The Navy has determined that, in a 24-hour period, all sonar activities in the MIRC transmit for a subset of that time (Table F-12).

Table F-12: Duration of 53C Use During 24-hour Period

Exercise	Longest continuous interval of 53C use in 24-hour period
Multi-Strike Group	12 hours
TRACKEX-TORPEX	8 hours

The most conservative assumption for a single ping is that it harasses the entire population within the range (a gross over-estimate). However, the total harassable population for multiple pings will be even greater, since animal motion over the period in the Table F-12 can bring animals into range that otherwise would be out of the harassable population.

Animal Motion Expansion

Though animals often change course to swim in different directions, straight-line animal motion would bring the more animals into the harassment area than a "random walk" motion model. Since precise and accurate animal motion models exist more as speculation than documented fact and because the modeling requires an undisputable upper bound, calculation of the upper bound for MIRC modeling areas uses a straight-line animal motion assumption. This is a conservative assumption.

For a circular area, the straight-line motion in any direction produces the same increase in harassable population. However, since the ranges are non-circular polygons, choosing the initial fixed direction as perpendicular to the longest diagonal produces greater results than any other direction. Thus, the product of the longest diagonal and the distance the animals move in the period of interest gives an overestimate of the expansion in range modeling areas due to animal motion. The MIRC expansions use this estimate as an absolute upper bound on animal-motion expansion.

Figure F-22 illustrates an example that illustrates the overestimation, which occurs during the second arrow:

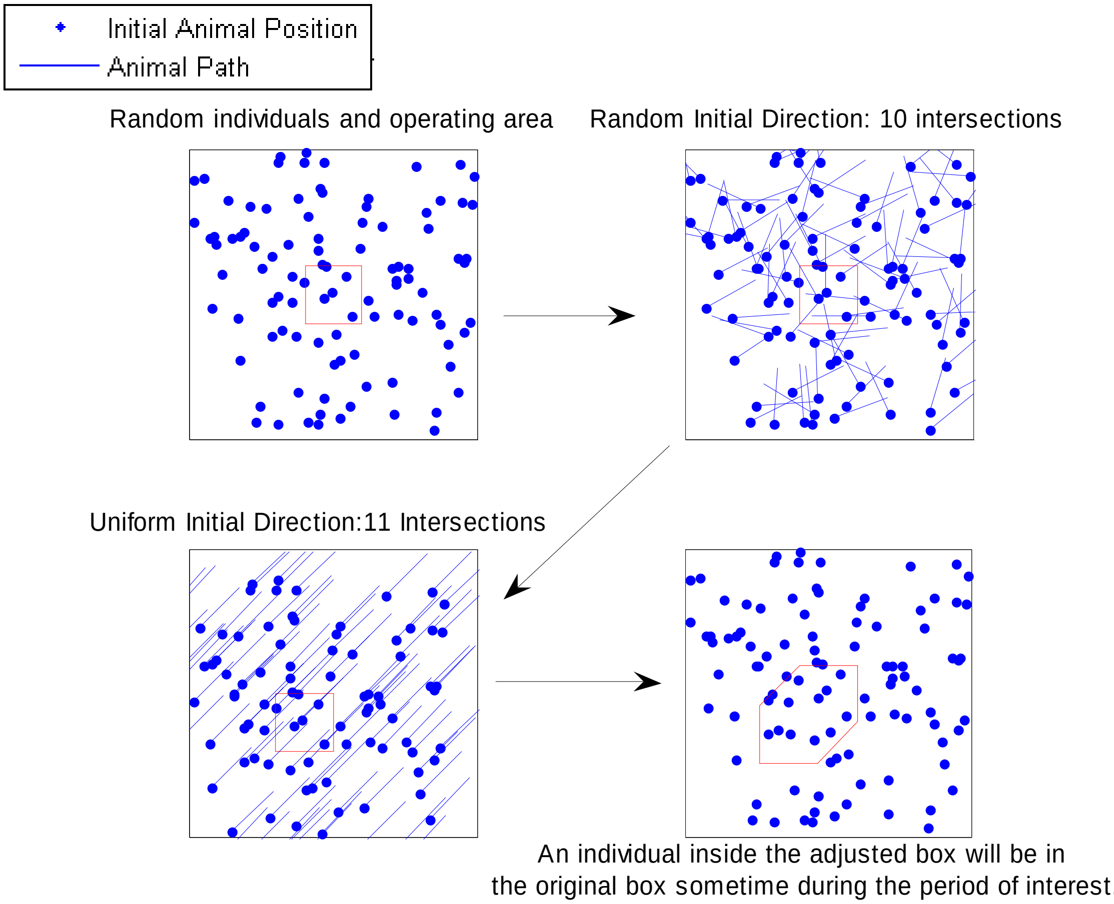


Figure F-22: Process of Setting an Upper Bound on Individuals Present in Area

It is important to recognize that the area used to calculate the harassable population, shown in Figure F-22 will, in general, be much larger than the area that will be within the ZOI of a ship for the duration of its broadcasts. For a source moving faster than the speed of the marine animals, a better (and much smaller) estimate of the harassable population would be that within the straight line ZOI cylinder shown in Figure F-22. Using this smaller population would lead to a greater dilution of the unharassed population per ping and would greatly reduce the estimated harassment.

Risk Function Expansion

The expanded area contains the number of animals that will enter the range over the period of interest. However, an upper bound on harassments must also include animals outside the area that would be affected by a source transmitting from the area's edge. A gross overestimation could simply assume pinging at every point on the range border throughout the exercise and would include all area with levels from a source on the closest border point greater than the risk function basement. In the case of MIRC, this would include all area within approximately 150 km from the edge of the adjusted box. This basic method would give a crude and exaggerated upper bound, since only a tiny fraction of this out-of-range area can be ensonified above threshold for a given ping. A more refined upper bound on harassments can be found by maintaining the assumption that a sonar is transmitting from each point in the adjusted box and calculating the expected ensonified area, which would give all animals inside the area a 100 percent probability of harassment, and those outside the area a varying probability, based on the risk function.

$$\int_0^{L^{-1}(120\,dB)} D(L(r))dr \quad ,$$

Where L is the SPL function with domain in range and range in level,
r is the range from the sonar operating area,
L^{-1}(120 dB) is the range at which the received level drops to 120 dB, and
D is the risk function (probability of harassment vs. level).

At the corners of the polygon, additional area can be expressed as

$$\frac{[\pi - \theta] \int_0^{L^{-1}(120\,dB)} D(L(r))rdr}{2\pi}$$

with D, L, and r as above, and
θ the inner angle of the polygon corner, in radians.

For the risk function and transmission loss of the MIRC, this method adds an area equivalent by expanding the boundaries of the adjusted box by four kilometers. The resulting shape, the adjusted box with a boundary expansion of 4 km, does not possess special meaning for the problem. But the number of individuals contained by that shape, is the harassable population and an absolute upper bound on possible harassments for that operation.

Figure F-23 illustrates the growth of area for the sample case above. The shapes of the boxes are unimportant. The area after the final expansion, though, gives an upper bound on the "harassable," or initially unharassed population which could be affected by training activities.

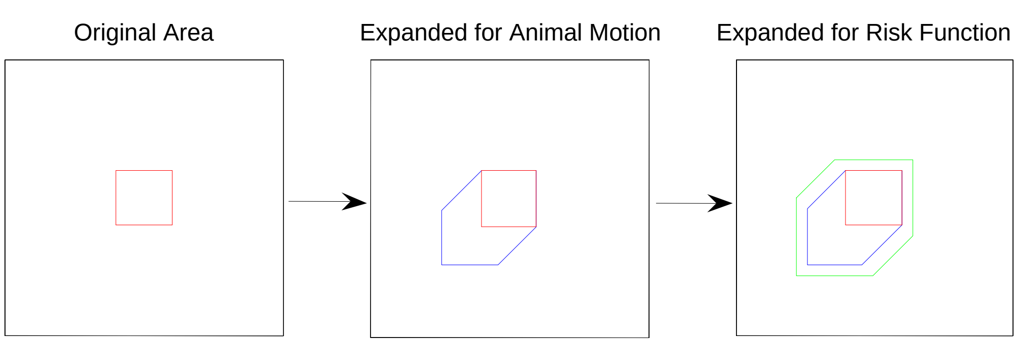


Figure F-23: Process of Expanding Area to Create Upper Bound of Harassments

For the most powerful source, the 53C, the expected winter rate of harassment for pantropical spotted dolphins is approximately 0.133743 harassments per ping. The exercise will transmit sonar pings for 12 hours in a 24 hour period, as given in the action table above, with 120 pings per hour, a total of 120*12=1,440 pings in a 24 hour period.

The MIRC has an area of approximately 1,872,094 square kilometers and a diagonal of 1,940 km. Adjusting this with straight-line (upper bound) animal motion of 5.5 kilometers per hour for 12 hours, animal motion adds 1,940*5.5*12= 128,040 square kilometers to the area. Using the risk function to calculate the expected range outside the MIRC adds another 20,728 square kilometers, bringing the total upper-bound of the affected area to 2,020,862 square km.

For this analysis, pantropical spotted dolphins have an average density of 0.0226 animals per square kilometer, so the upper bound number of pantropical spotted dolphins that can be affected by 53C activity in the MIRC during a 24 hour period is 2,020,862 *0.0226=45,671 dolphins.

In the first ping, 0.133743 pantropical spotted dolphins will be harassed. With the second ping, $0.133743\left(\frac{45671-0.133743}{45671}\right)=0.13374261$ pantropical spotted dolphins will be harassed.

Using the formula derived above, after 12 hours of continuous operation, the remaining **unharassed** population is $P_{1440}=P_0\left(1-\left(\frac{h}{P_0}\right)\right)^{1440}=45671\left(1-\left(\frac{0.133743}{45671}\right)\right)^{1440}\approx 45478.82$

So the **harassed** population will be 45671-45478.82 = 192.18 animals.

Contrast this with linear accumulation of harassments without consideration of the local population and the dilution of the unharassed population:

Harassments = 0.133743 *1,440=192.6 animals

The difference in harassments is very small, as a percentage of total harassments, because the size of the MIRC implies a large “harassable” population relative to the harassment per ping of the 53C. In cases where the harassable population is not as large, with respect to the per ping harassments, the difference in harassments between linear accumulation and density dilution is more pronounced. Note that these numbers were calculated without consideration of land-shadow and multiple-ship effects.

F.6.3.2 Land Shadow

The risk function considers harassment possible if an animal receives 120 dB SPL, or above. In the open ocean of the MIRC, this can occur as far away as 150 km, so over a large "effect" area, sonar sound could, but does not necessarily, harass an animal. The harassment calculations for a general modeling case must assume that this effect area covers only water fully populated with animals, but in some portions of the MIRC, land partially encroaches on the area, obstructing sound propagation.

As discussed in the introduction of "Additional Modeling Considerations" Navy planners do not know the exact location and transmission direction of the sonars at future times. These factors however, completely determine the interference of the land with the sound, or "land shadow," so a general modeling approach does not have enough information to compute the land shadow effects directly. However, modelers can predict the reduction in harassments at any point due to land shadow for different pointing directions and use expected probability distribution of activity to calculate the average land shadow for operations in each range.

For the ranges, in each alternative, the land shadow is computed over a dense grid in each operations area. Figure F-24 shows the grid for the MIRC.

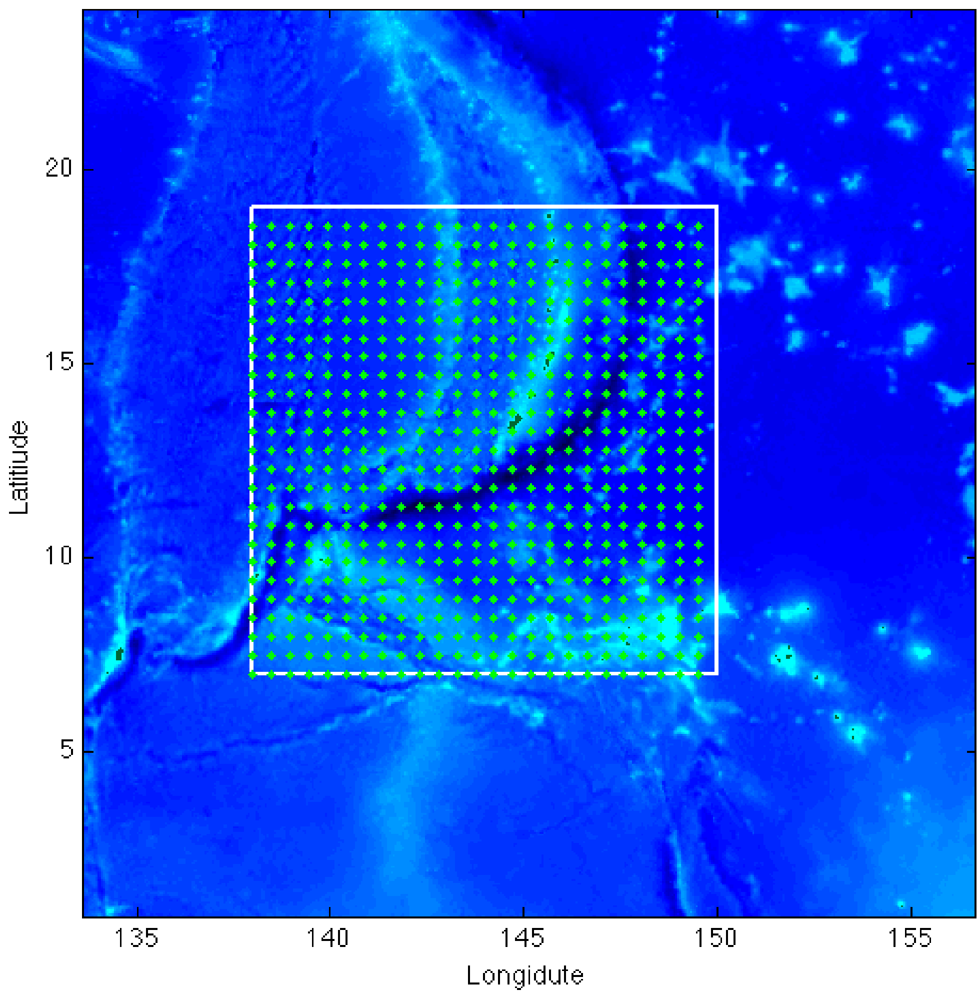


Figure F-24: Illustrative Grid for MIRC Study Area. Each green point represents approximately 100 points on the actual grid used for land shadow calculation, which samples every km.

For each of the coastal points that are within 150 km of the grid, the azimuth and distance is computed. In the computation, only the minimum range at each azimuth is computed. Figure F-25 shows the minimum range compared with azimuth for the sample point.

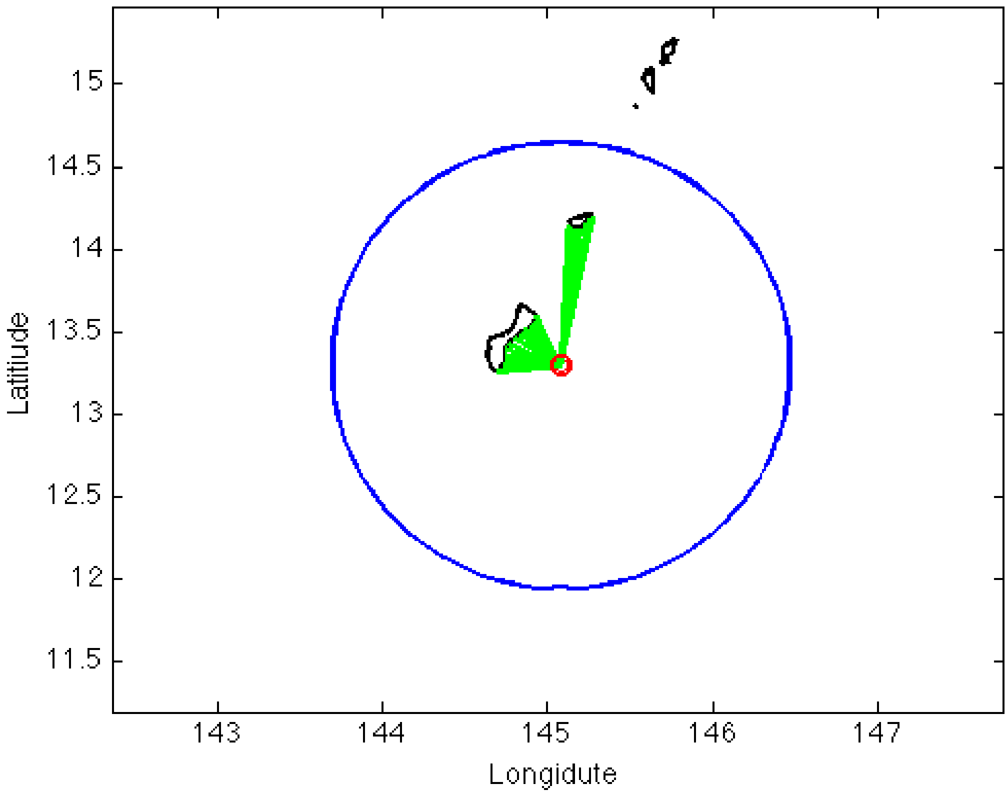


Figure F-25: The nearest point at each azimuth (with 1^{o} spacing) to a sample grid point (red circle) is shown by the green lines.

Now, the average of the distances to shore, along with the angular profile of land is computed (by summing the unique azimuths that intersect the coast) for each grid point. The values are then used to compute the land shadow for the grid points.

Computing the Land Shadow Effect at Each Grid Point

The effect of land shadow is computed by determining the levels, and thus the distances from the sources, that the harassments occur. Table F-13 gives a mathematical extrapolation of the distances and levels at which harassments occur, with average propagation in the MIRC. Figure F-26 provides the percentage of behavioral harassments for every 5-degree band of received level from the 53C/D sonar.

Table F-13: Behavioral Harassments at each Received Level Band from 53C

Received Level (dB SPL)	Distance at which Levels Occur in MIRC	Percent of Behavioral Harassments Occurring at Given Levels
Below 150	15 km - 150 km	< 2%
150>Level>160	6 km – 15 km	18%
160>Level>170	2 km – 6 km	41%
170>Level>180	0.5 km – 2 km	27%
180>Level>190	170 m – 500 m	10%
Above 190 dB	0 m – 170 m	<3%

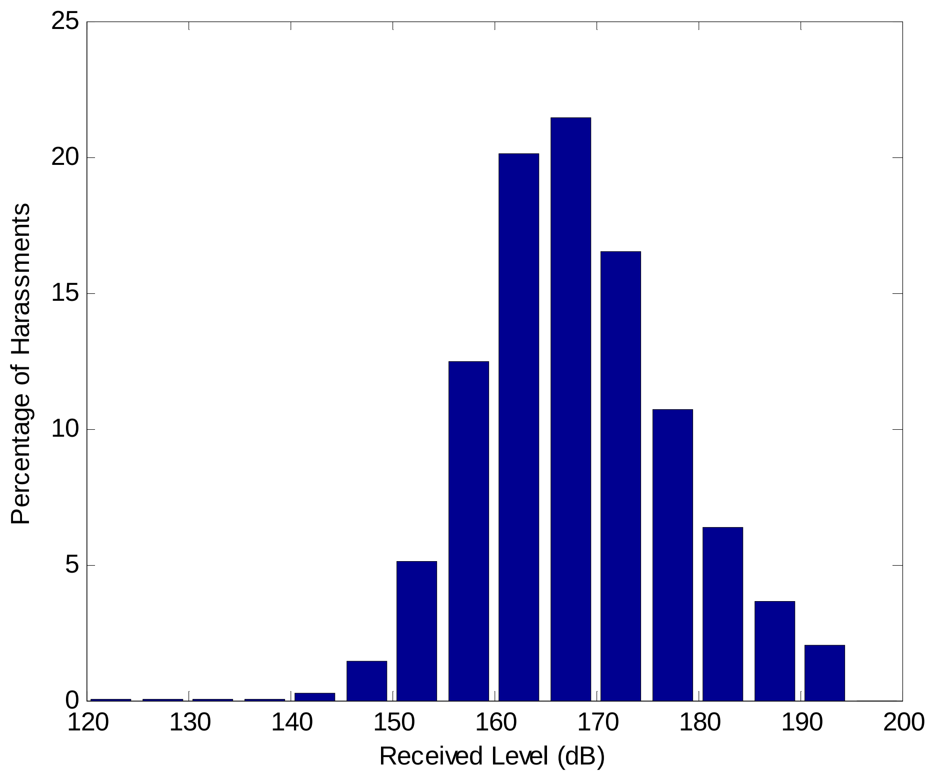


Figure F-26: The approximate percentage of behavioral harassments for every 5 degree band of received level from the 53C

With the data used to produce the previous figure, the average effect reduction across season for a sound path blocked by land can be calculated. For the 53C, since approximately 94 percent of harassments occur within 10 kilometers of the source, a sound path blocked by land at 10 kilometers will, on average, cause approximately 94 percent the effect of an unblocked path, as shown in Figure F-27.

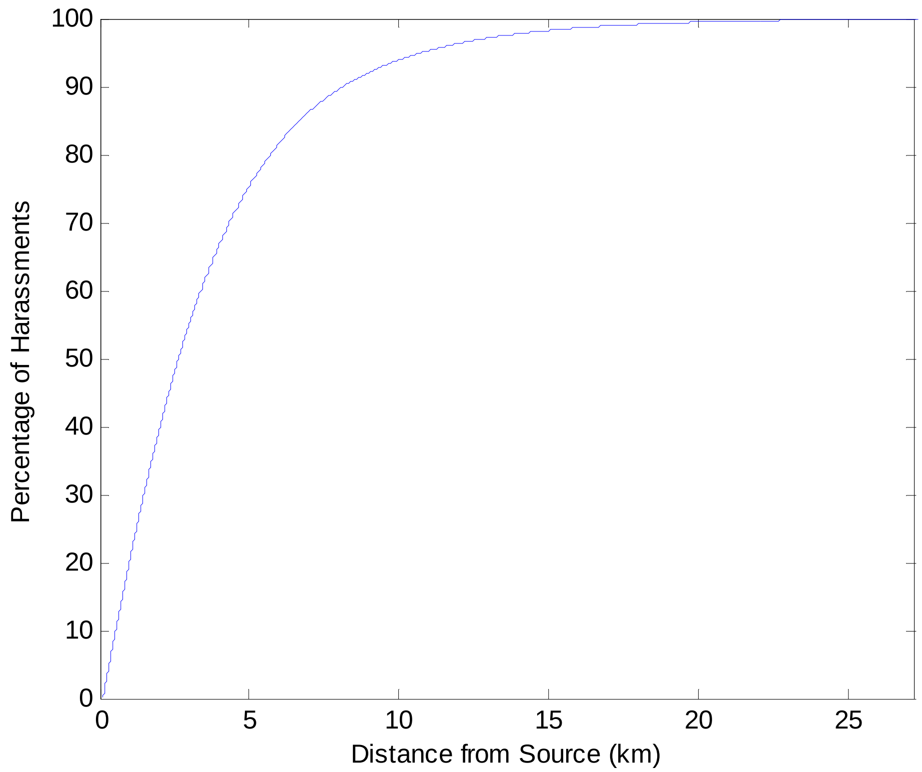


Figure F-27: Average Percentage of Harassments Occurring Within a Given Distance

As described above, the mapping process determines the angular profile of and distance to the coastline(s) from each grid point. The distance, then, determines the reduction due to land shadow when the sonar is pointed in that direction. The angular profile, then, determines the probability that the sonar is pointed at the coast.

Define θ_n = angular profile of coastline at point n in radians

Define r_n = mean distance to shoreline

Define A(r) = average effect adjustment factor for sound blocked at distance r

The land shadow at point n can be approximated by $A(r_n)\theta_n/(2\pi)$. For illustration, the following plots give the land shadow reduction factor at each point in each range area for the 53C. The white portions of the plot indicate the areas outside the range and the blue lines indicate the coastline. The color plots inside the ranges give the land shadow factor at each point. The average land shadow factor for the 53C in the MIRC is 0.9997, or the reduction in effect is 0.03 percent. For the other, lower-power sources, this reduction is lower. The effect of land shadow in the MIRC is also negligible.

F.6.3.3 The Effect of Multiple Ships

Behavioral harassment, under risk function, uses maximum SPL over a 24-hour period as the metric for determining the probability of harassment. An animal that receives sound from two sonars, operating simultaneously, receives its maximum SPL from one of the ships. Thus, the effects of the louder, or closer, sonar determine the probability of harassment, and the more distant sonar does not. If the distant sonar operated by itself, it would create a lesser effect on the animal, but in the presence of a more dominating sound, its effects are cancelled. When two sources are sufficiently close together, their sound fields within the cutoff range will partially overlap and the larger of the two sound fields at each point in that overlap cancel the weaker. If the distance between sources is twice as large as the range to cutoff, there will be no overlap.

Computation of the overlap between sound fields requires the precise locations and number of the source ships. The general modeling scenarios of the MIRC do not have these parameters, so the effect was modeled using an average ship distance, 20 km, and an average number of ships per exercise. The number of ships per exercise varied based on the type of exercise, as given in Table F-14.

Table F-14: Average Number of 53C-Transmitting Ships in the MIRC Exercise Types

Action	Average Number of SQS-53C-Transmitting Ships
Multi-Strike Group	4
TRACKEX-TORPEX	1.5

The formation of ships in any of the above exercise has been determined by Navy planners. The ships are located in a straight line, perpendicular to the direction traveled. Figures F-28 and F-29 show examples with four ships, and their ship tracks.

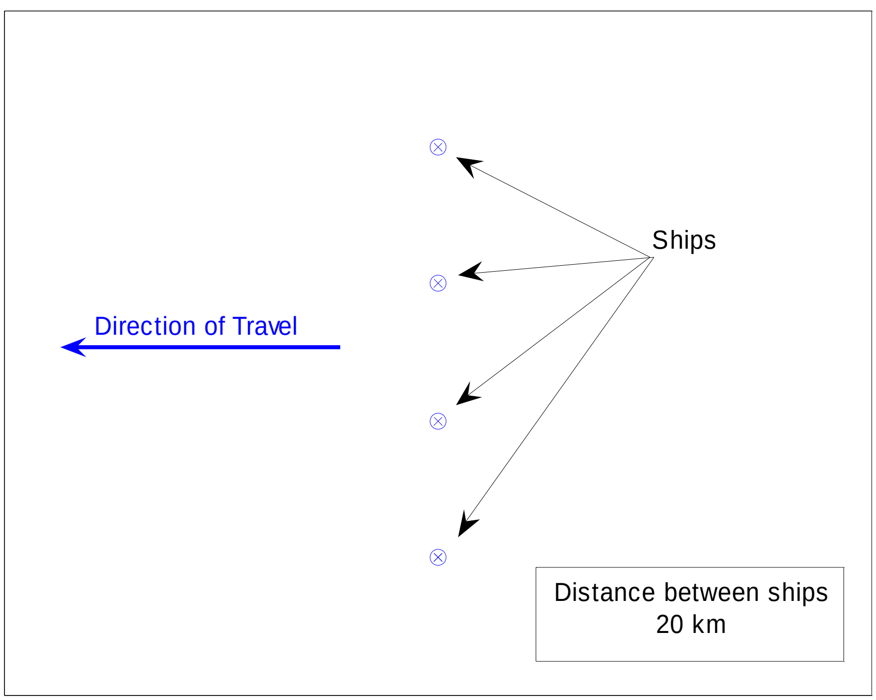


Figure F-28: Formation and Bearing of Ships in Four-Ship Example

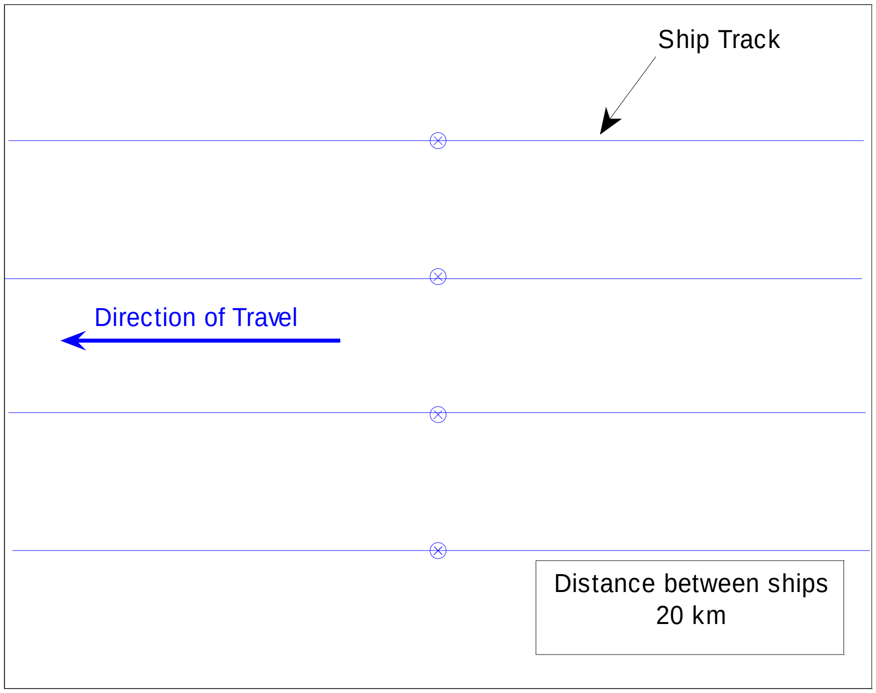


Figure F-29: Ship Tracks of Ships in 4-Ship Example

The sound field created by these ships, which transmit sonar continually as they travel will be uniform in the direction of travel (or the "x" direction), and vary by distance from the ship track in the direction perpendicular to the direction of travel (or the "y" direction) (Figure F-30).

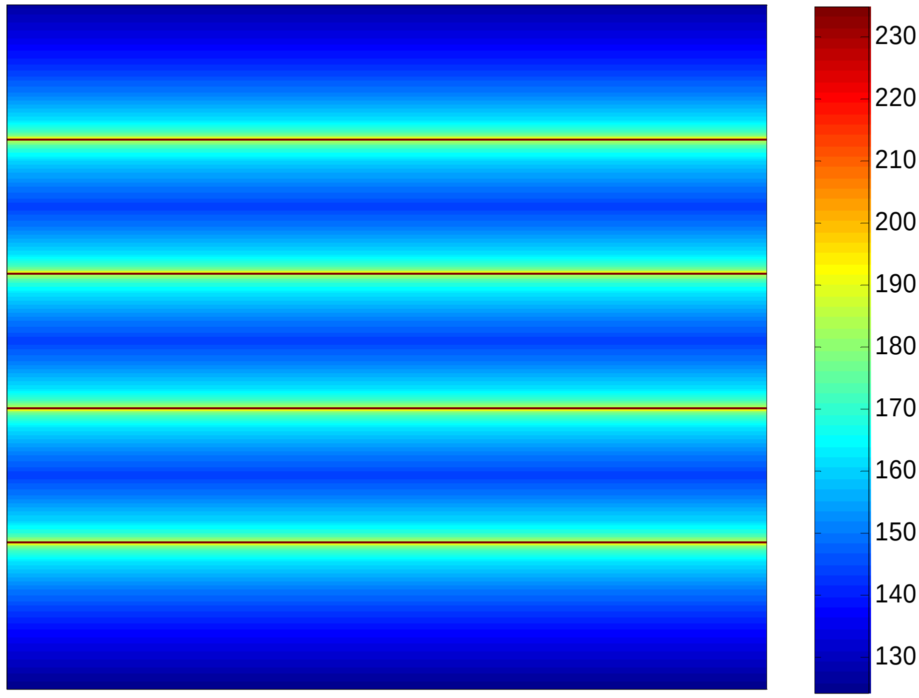


Figure F-30: Sound Field Produced by Multiple Ships

This sound field of the four ships operating together ensonifies less area than four ships operating individually. At the time of modeling, even the average number of ships and mean distances between them were unknown, so a post-calculation correction should be applied.

Referring to the above picture of the sound field around the ship tracks, the portion above the upper-most ship track, and the portion below the lower-most ship track sum to produce exactly the sound field as an individual ship.

Therefore, the remaining portion of the sound field, between the uppermost ship track and the lowermost ship track, is the contribution of the three additional ships (Figure F-31).

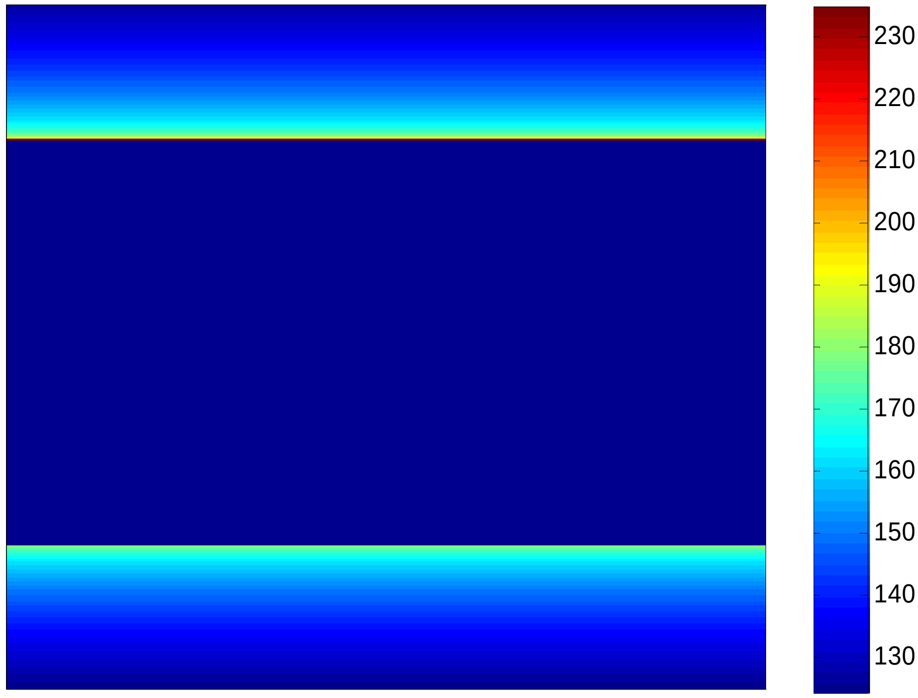


Figure F-31: Upper and Lower Portion of Sound Field

This remaining sound field is made up of three bands (Figure F-32). Each of the three additional ships contributes one band to the sound field. Each band is somewhat less than the contribution of the individual ship because its sound is overcome by the nearer source at the center of the band. Since each ship maintains 20 kilometer distance between it and the next, the height of these bands is 20 km, and the sound from each side projects 10 kilometers before it is overcome by the source on the other side of the band. Thus, the contribution to a sound field for an additional ship is identical to that produced by an individual ship whose sound path is obstructed at 10 kilometers. The work in the previous discussion on land shadow provides a calculation of effect reduction for obstructed sound at each range. An AQS-53C-transmitting ship with obstructed signal at 10 kilometers causes 94 percent of the number of harassments as a ship with an unobstructed signal. Therefore, each additional ship causes 0.94 times the harassments of the individual ship. Applying this factor to the exercise types, an adjustment from the results for a single ship can be applied to predict the effects of multiple ships (Table F-15).

Table F-15: Adjustment Factors for Multiple Ships in MIRC Exercise Types

Action	Average Number of SQS-53C-Transmitting Ships	Adjustment Factor from Individual Ship for Formation and Distance
Multi-Strike Group	4	3.82
TRACKEX-TORPEX	2	1.94

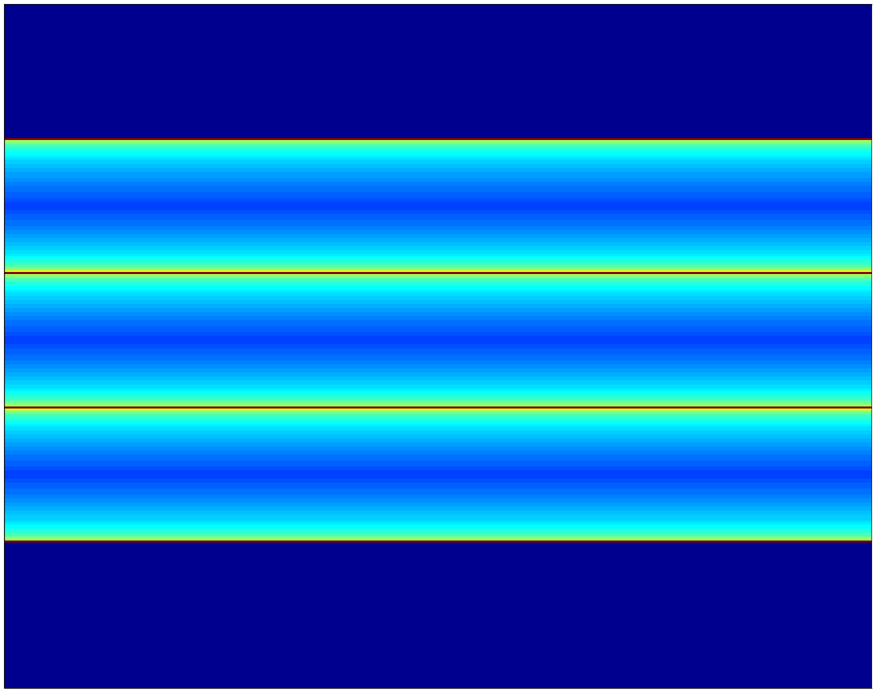


Figure F-32: Central Portion of Sound Field

F.7 References

Arons, A.B. (1954). "Underwater Explosion Shock Wave Parameters at Large Distances from the Charge," J. Acoust. Soc. Am. 26, 343.

Bartberger, C.L. (1965). "Lecture Notes on Underwater Acoustics," NADC Report NADC=WR-6509, Naval Air Development Center Technical Report, Johnsville, PA, 17 May (AD 468 869) (UNCLASSIFIED).

Christian, E.A. and J.B. Gaspin, (1974). Swimmer Safe Standoffs from Underwater Explosions," NSAP Project PHP-11-73, Naval Ordnance Laboratory, Report NOLX-89, 1 July (UNCLASSIFIED).

Department of the Navy (1998), "Final Environmental Impact Statement, Shock Testing the SEAWOLF Submarine," U.S. Department of the Navy, Southern Division, Naval Facilities Engineering Command, North Charleston, SC, 637 p.

Department of the Navy (2001), "Final Environmental Impact Statement, Shock Trial of the WINSTON S. CHURCHILL (DDG 81)," U.S. Department of the Navy, NAVSEA, 597 p.

Goertner, J.F. (1982). "Prediction of Underwater Explosion Save Ranges for Sea Mammals," Naval Surface Warfare Center (NSWC) Report NSCW TR 82-188, NSWC, Dahlgren, VA (UNCLASSIFIED).

Goertner, J.F. (1982), "Prediction of Underwater Explosion Safe Ranges for Sea Mammals," NSWC TR 82-188, Naval Surface Weapons Center, Dahlgren, VA.

Keenan, R.E., Denise Brown, Emily McCarthy, Henry Weinberg, and Frank Aidala (2000). "Software Design Description for the Comprehensive Acoustic System Simulation (CASS Version 3.0) with the Gaussian Ray Bundle Model (GRAB Version 2.0)", NUWC-NPT Technical Document 11,231, Naval Undersea Warfare Center Division, Newport, RI, 1 June (UNCLASSIFIED).

McGrath, J.R. (1971). "Scaling Laws for Underwater Exploding Wires," J. Acoust. Soc. Am. 50, 1030-1033 (UNCLASSIFIED).

Urick, R.J. (1983). Principles of Underwater Sound for Engineers, McGraw-Hill, NY (first edition: 1967, second edition: 1975) (UNCLASSIFIED).

Weston, D.E. (1960). "Underwater Explosions as Acoustic Sources," Proc. Phys. Soc. 76, 233 (UNCLASSIFIED).

APPENDIX G

MARINE MAMMAL DENSITY

Marine mammal density and depth distribution for MIRC

This Page Intentionally Left Blank

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

Appendix G

Marine Mammal Density and Depth Distribution for Mariana Islands Range Complex

Marine mammal species occurring in the western Pacific near the Marianas include baleen whales (mysticetes), toothed whales (odontocetes), seals (carnivores commonly referred to as pinniped) and the dugong (sirenian). Baleen and toothed whales, collectively known as cetaceans, spend their entire lives in the water and spend most of the time (>90% for most species) entirely submerged below the surface. When at the surface, cetacean bodies are almost entirely below the water's surface, with only the blowhole exposed to allow breathing. This makes cetaceans difficult to locate visually and also exposes them to underwater noise, both natural and anthropogenic, essentially 100% of the time because their ears are nearly always below the water's surface. Seals and sea lions (pinnipeds) spend significant amounts of time out of the water during breeding, molting and hauling out periods. In the water, pinnipeds spend varying amounts of time underwater, as some species regularly undertake long, deep dives (e.g., elephant seals) and others are known to rest at the surface in large groups for long amounts of time (e.g., California sea lions). When not actively diving, pinnipeds at the surface often orient their bodies vertically in the water column and often hold their heads above the water surface. Consequently, pinnipeds may not be exposed to underwater sounds to the same extent as cetaceans. Dugongs also spend their entire lives in the water, and usually raise only the nostrils above the water's surface to breathe, which also exposes them to underwater noise essentially 100% of the time.

For the purposes of this analysis, we have adopted a conservative approach to underwater noise and marine mammals:

- Cetaceans – assume 100% of time is spent underwater and therefore exposed to noise
- Pinnipeds – adjust densities to account for time periods spent at breeding areas, haulouts, etc.; but for those animals in the water, assume 100% of time is spent underwater and therefore exposed to noise
- Sirenians – assume 100% of time is spent underwater and therefore exposed to noise

This document is organized into taxonomic categories: mysticetes, odontocetes, carnivores (pinnipeds), and sirenian. Nomenclature was adopted from the Integrated Taxonomic Information System (www.itis.gov).

G.1 DENSITY

The Mariana Islands have not been extensively surveyed for marine mammals. The Marine Resources Assessment for the Marianas Operating Area (DoN, 2005) listed 20 species of marine mammal as regularly occurring in the area, with 12 additional species considered "rare" or "extralimital" (see Table 3-1, DoN, 2005).

A vessel survey was conducted in January-April 2007 specifically to determine marine mammal abundance and densities in the Mariana archipelago (SRS-Parsons et al., 2007). Densities were derived for 16 species/species groups based on analysis of data collected during this survey (Table 3-5 in SRS-Parsons et al., 2007), and provided to SAIC as GFI. *The authors of the report indicate that "abundance and density estimates for those species analyzed are underestimated" because there was no correction for animals below the water's surface and/or not detected.* These densities have been included in this document exactly as provided in the report. Conditions during the surveys were marginal, with higher than desired sea states. Likely due to these conditions, cryptic species (beaked whales, *Kogia* sp) were not seen at all.

Densities for species known to occur regularly or whose distributions likely encompass the Marianas (those having regular or rare occurrence), and which were not seen during the 2007 survey effort, were extrapolated by SAIC from other Pacific Ocean geographic areas and referenced appropriately. Note that these extrapolated densities are likely *not underestimates* of density because correction factors were included in analysis (e.g., Ferguson and Barlow, 2003: Barlow, 2006).

Marine mammal densities and other pertinent information are presented in Table I-1 and are **bolded** in the text. The Mariana Survey area and the MIRC are depicted in Figure I-1.

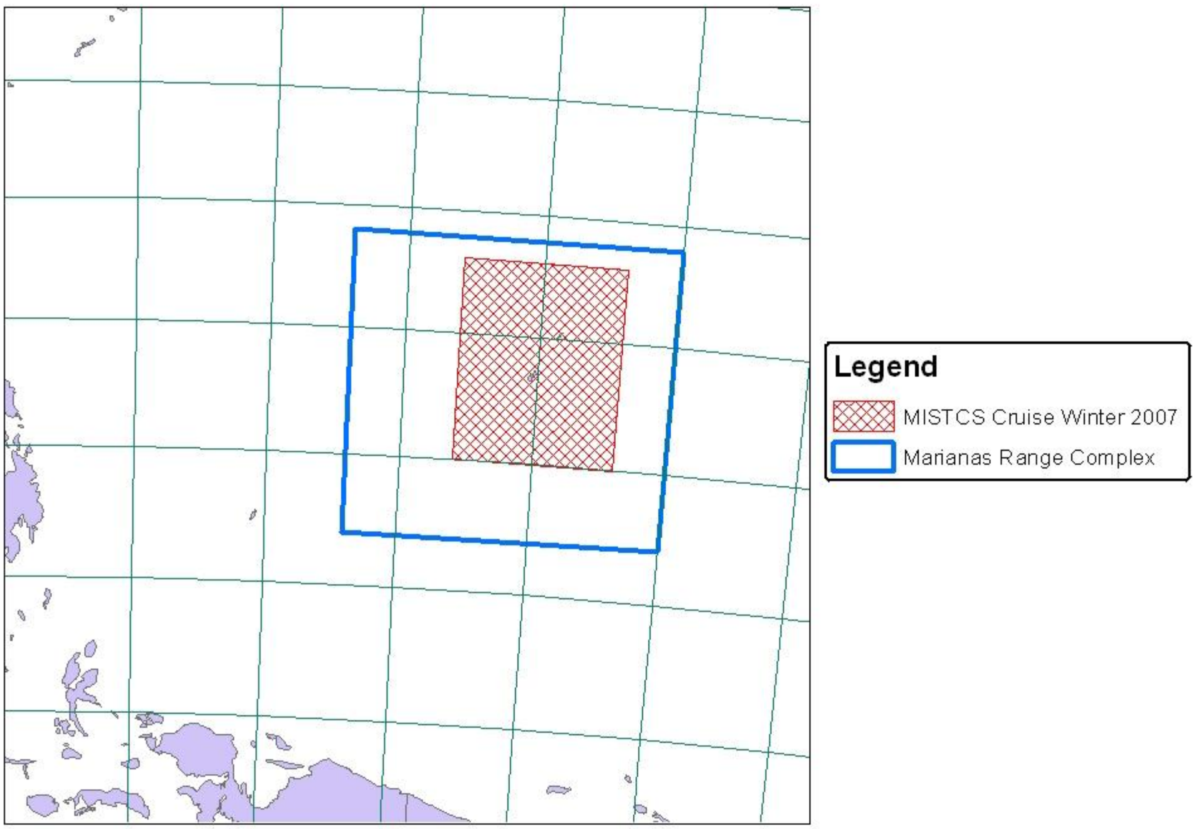


Figure G-1. MIRC Study Area and the Mariana Islands Sea Turtle and Cetacean Survey (MISTCS) study area.

Table G-1. Summary of Marine Mammal Species in the MIRC

Common Name	Scientific Name	Status	Density/km²	Source	Notes
MYSTICETES					
Blue whale	*Balaenoptera musculus*	E	0.0001	Ferguson and Barlow, 2003	
Fin whale	*B. physalus*	E	0.0003	Ferguson and Barlow, 2003	
Sei whale	*B. borealis*	E	0.00029	SRS-Parsons et al., 2007	
Bryde's whale	*B. edeni*		0.00041	SRS-Parsons et al., 2007	
Sei/Bryde's whale	*B. borealis/edeni*		0.000056	SRS-Parsons et al., 2007	
Minke whale	*B. acutorostrata*		0.0004	SRS-Parsons et al., 2007; Ferguson and Barlow, 2003	several acoustic detections in winter 2007; no visual observations; density from Ferguson and Barlow (2003)
Unidentified Balaenopterid	*Balaenoptera sp.*		0.00012	SRS-Parsons et al., 2007	
Humpback whale	*Megaptera novaeangliae*	E	0.0069	Ferguson and Barlow, 2003; SRS-Parsons et al., 2007	applicable for Oct-May only (not expected in Jun-Sep); Marianas may be within winter breeding range; one sighting and several acoustic detections in winter 2007
ODONTOCETES					
Sperm whale	*Physeter catodon*	E	0.00123	SRS-Parsons et al., 2007	
Pygmy and dwarf sperm whales	*Kogia sp.*		0.0078	Barlow, 2006	
Cuvier's beaked whale	*Ziphius cavirostris*		0.0052	Barlow, 2006	
Blainville's beaked whale	*Mesoplodon densirostris*		0.0009	Barlow, 2006	
Gingko-toothed beaked whale	*M. ginkgodens*		0.0005	Ferguson and Barlow, 2003	
Longman's beaked whale	*Indopacetus pacificus*		0.0003	Barlow, 2006	
Killer whale	*Orcinus orca*		0.0002	Barlow, 2006	
False killer whale	*Pseudorca crassidens*		0.00111	SRS-Parsons et al., 2007	
Pygmy killer whale	*Feresa attenuata*		0.00014	SRS-Parsons et al., 2007	
Short-finned pilot whale	*Globicephala macrorhynchus*		0.00159	SRS-Parsons et al., 2007	
Risso's dolphin	*Grampus griseus*		0.0106	Miyashita, 1993	
Melon-headed whale	*Peponocephala electra*		0.00428	SRS-Parsons et al., 2007	
Fraser's dolphin	*Lagenodelphis hosei*		0.0069	Barlow, 2006	
Bottlenose dolphin	*Tursiops truncatus*		0.00021	SRS-Parsons et al., 2007	
Rough-toothed dolphin	*Steno bredanensis*		0.00029	SRS-Parsons et al., 2007	
Bottlenose/Rough-toothed	*Tursiops/Steno*		0.00009	SRS-Parsons et al., 2007	
Short-beaked common dolphin	*Delphinus delphis*		0.0021	Ferguson and Barlow, 2003	
Striped dolphin	*Stenella coeruleoalba*		0.00616	SRS-Parsons et al., 2007	
Spinner dolphin	*S. longirostris*		0.00314	SRS-Parsons et al., 2007	
Pantropical spotted dolphin	*S. attenuata*		0.0226	SRS-Parsons et al., 2007	
Unidentified delphinid			0.00107	SRS-Parsons et al., 2007	

G.2 DEPTH DISTRIBUTION

There are limited depth distribution data for most marine mammals. This is especially true for cetaceans, as they must be tagged at-sea and by using a tag that either must be implanted in the skin/blubber in some manner or adhere to the skin. There is slightly more data for some pinnipeds, as they can be tagged while on shore during breeding or molting seasons and the tags can be glued to the pelage rather than implanted. There are a few different methodologies/ techniques that can be used to determine depth distribution percentages, but by far the most widely used technique currently is the time-depth recorder. These instruments are attached to the animal for a fairly short period of time (several hours to a few days) via a suction cup or glue, and then retrieved immediately after detachment or (for pinnipeds) when the animal returns to the beach. Depth information can also be collected via satellite tags, sonic tags, digital tags, and, for sperm and beaked whales, via acoustic tracking of sounds produced by the animal itself.

There are somewhat suitable depth distribution data for some marine mammal species. Sample sizes are usually extremely small, nearly always fewer than 10 animals total and often only 1 or 2 animals. Depth distribution information can also be interpreted from other dive and/or preferred prey characteristics, and from methods including behavioral observations, stomach content analysis and habitat preference analysis. Depth distributions for species for which no data are available are extrapolated from similar species.

Depth distribution information was researched by SAIC, and is included for those species for which a density is available for the Marianas region, either from the 2007 survey or extrapolated from elsewhere. Depth info is **bolded** in text. Detailed depth information compiled by SAIC for marine mammal species in the MIRC Study Area for which densities are available is also included in Appendix A.

G.3 DENSITY AND DEPTH DISTRIBUTION COMBINED

Density is nearly always reported for an area, e.g., animals/square kilometer (m^2). Analyses of survey results using Distance Sampling techniques usually include correction factors for animals at the surface but not seen as well as animals below the surface and not seen. Therefore, although the area (e.g., km^2) appears to represent only the surface of the water (two-dimensional), density actually implicitly includes animals anywhere within the water column under that surface area. Density assumes that animals are uniformly distributed within the prescribed area, even though this is likely rarely true. Marine mammals are usually clumped in areas of greater importance, for example, areas of high productivity, lower predation, safe calving, etc. Density can occasionally be calculated for smaller areas that are used regularly by marine mammals, but more often than not there are insufficient data to calculate density for small areas. Therefore, assuming an even distribution within the prescribed area remains the norm.

Assuming that marine mammals are distributed evenly within the water column does not accurately reflect marine mammal behavior. The ever-expanding database of marine mammal behavioral and physiological parameters obtained through tagging and other technologies has demonstrated that marine mammals use the water column in various ways, with some species capable of regular deep dives (>800 meters [m]) and others diving to <200 m, regardless of the bottom depth. Assuming that all species are evenly distributed from surface to bottom is almost never appropriate and can present a distorted view of marine mammal distribution in any region.

By combining marine mammal density with depth distribution information, a three-dimensional density estimate is possible. These 3-D estimates allow more accurate modeling of potential marine mammal exposures from specific noise sources.

G.4 MYSTICETES

G.4.1 Blue whale, Balaenoptera musculus—Rare

Between two and five stocks of blue whales exist in the North Pacific, with the best known and studied population inhabiting the eastern North Pacific (Sears, 2002); far less information exists for the stock(s) in the western North Pacific. Blue whales are considered rare in the Marianas region (DoN, 2005), but their distribution range likely overlaps with the area. No blue whales were seen during the 2007 vessel survey (SRS-Parsons et al., 2007). Density for blue whales in the Eastern Tropical Pacific (ETP) ranged from 0.0001 to 0.0035/km^2 (Ferguson and Barlow, 2003). Due to the rare status and complete lack of sightings in the Marianas, **the lowest density (0.0001/km^2) reported for the ETP will be used for this area and is applicable year round.**

Blue whales feed on euphausiid crustaceans, including *Euphausia* sp and *Thysanoessa* sp (Sears, 2002). They have been documented feeding near the surface as well as at depths exceeding 140 m (Croll et al., 2001a). Data from southern California and Mexico showed that whales dived to >100 m for foraging; once at depth, vertical lunge-feeding often occurred (lunging after prey). Lunge-feeding at depth is energetically expensive and likely limits the deeper diving capability of blue whales. Foraging dives were deeper than traveling dives; traveling dives were generally to ~ 30 m. Typical dive shape was somewhat V-shaped, although the bottom of the V was wide to account for the vertical lunges at bottom of dive. Blue whales also have shallower foraging dives. **Best info for % of time at depth is from Lagerquist et al (2000; Figure 2): 78% in 0-16 m, 9% in 17-32 m, 13% in >32 m;** most dives were to <16 m and 96-152 m ranges, but only 1.2% of total time was spent in deeper range.

G.4.2 Fin whale, Balaenoptera physalus—Rare

Fin whales occur in all oceans in temperate to polar latitudes, and many populations undergo seasonal migrations, from low latitude breeding areas to higher latitude feeding areas (Aguilar, 2002). Fin whales are considered rare in the Marianas region (DoN, 2005), but their distribution range likely overlaps with the area. No fin whales were seen during the 2007 vessel survey (SRS-Parsons et al., 2007). Density for fin whales in the ETP ranged from 0.0003 to 0.0054/km^2 (Ferguson and Barlow, 2003). Due to the rare status and complete lack of sightings in the Marianas, **the lowest density (0.0003/km^2) reported for the ETP will be used for this area and is applicable year round.**

Fin whales feed on planktonic crustaceans, including *Thysanoessa* sp and *Calanus* sp, as well as schooling fish including herring, capelin and mackerel (Aguilar, 2002). Depth distribution data from the Ligurian Sea in the Mediterranean are the most complete (Panigada et al., 2003), and showed differences between day and night diving; daytime dives were shallower (<100m) and night dives were deeper (>400m), likely taking advantage of nocturnal prey migrations into shallower depths; this data may be atypical of fin whales elsewhere in areas where they do not feed on vertically-migrating prey. Goldbogen et al. (2006) studied fin whales in southern California and found that 60% of total time was spent diving, with the other 40% near surface (<50m); dives were to >225 m and were characterized by rapid gliding ascent, foraging lunges near the bottom of dive, and rapid ascent with flukes. Dives were somewhat V-shaped although the bottom of the V was wide. **Based on this information, percentage of time at depth levels is estimated as 40% at <50m, 20% at 50-225 m (covering the ascent and descent times) and 40% at >225 m.**

G.4.3 Sei whale, Balaenoptera borealis—Regular

Sei whales occur in all oceans from subtropical to sub-arctic waters, and can be found on the shelf as well as in oceanic waters (Reeves et al., 2002). Sei whales were considered extralimital in the Marianas area (DoN, 2005), however they were visually and acoustically located during the 2007 vessel survey (SRS-Parsons et al., 2007). **Density was calculated as 0.00029/km^2, which is applicable year round.**

Sei whales feed on copepods, amphipods, euphausiids, shoaling fish, and squid (Horwood, 2002). Stomach content analysis indicated that they are likely skim feeders that take in swarms in low density. Pauly et al. (1998) used stomach contents and morphological and behavioral information to standardize diet compositions for several marine mammals; based on this analysis, sei whales rely on large invertebrates for 80% of their diet, with the remaining components being small squids, small pelagics, mesopelagics and miscellaneous fishes. There have been no depth distribution data collected on this somewhat elusive species**. In lieu of depth data, minke whale depth distribution percentages will be extrapolated to sei whales: 53% at <20 m and 47% at 21-65 m.**

G.4.4 Bryde's whale, *Balaenoptera edeni*—Regular

Bryde's whales are found mainly in tropical and temperate waters, in areas of high productivity where water temperature is at least 16.3°C (Reeves et al., 2002; Kato, 2002). Bryde's whales were the most frequently sighted mysticete during the 2007 vessel survey (SRS-Parsons et al., 2007)**. Density was calculated as 0.00041/km^2, which is applicable year round.**

Bryde's whales feed on pelagic schooling fish, small crustaceans including euphausiids and copepods and cephalopods (Kato, 2002). Diet composition analyzed by Pauly et al. (1998) indicated 40% of the diet was large zooplankton with 60% composed of small pelagics, mesopelagics and miscellaneous fishes. Feeding appears to be regionally different. Off South Africa, the inshore form feeds on epipelagic fish while the offshore form feeds on mesopelagic fish and euphausiids (Best, 1977; Bannister, 2002). Stomach content analysis from whales in the southern Pacific and Indian oceans indicated that most feeding apparently occurred at dawn and dusk, and were primarily euphausiids (Kawamura, 1980). There have been no depth distribution data collected on Bryde's whales**. In lieu of depth data, minke whale depth distribution percentages will be extrapolated to Bryde's whales: 53% at <20 m and 47% at 21-65 m).**

G.4.5 Sei/Bryde's whale, Balaenoptera borealis/edeni—Regular

Bryde's and sei whales are difficult to differentiate at-sea, and many sightings cannot be definitively recorded as one or the other species during survey efforts. **The density for this combined species group from the 2007 vessel survey effort was 0.000056/km^2 (SRS-Parsons et al., 2007), which is applicable year round.**

There are no depth data for either of these mysticete species, so minke whale depth distribution percentages will be extrapolated to this group: **53% at <20 m and 47% at 21-65 m.**

G.4.6 Minke whale, Balaenoptera acutorostrata—Regular

Minke whales are the smallest of all mysticete whales, and often exhibit cryptic behaviors in tropical waters making them difficult to see. They are widely distributed in the north Atlantic and Pacific (Perrin and Brownell, 2002). Minke whales can be found in near shore shallow waters and have been detected acoustically in offshore deep waters. Most minke whale populations inhabit colder waters in summer and migrate to warmer regions in winter. Minke whales were considered rare in the Marianas (DoN, 2005), and they were not sighted during the 2007 vessel survey (SRS-Parsons et al., 2007). However, they were the most frequent acoustically detected mysticete, with 29 localizations near the Marianas Trench. Density for minke whales in the ETP ranged from 0.0002 to 0.0004/km^2 (Ferguson and

Barlow, 2003). Due to the relatively high number of acoustic detections, **the highest density (0.0004/ km^2) reported for the ETP will be used for this area.**

Minke whales feed on small schooling fish and krill, and are the smallest of all balaenopterid species which may affect their ability to dive. The only depth distribution data for this species were reported from a study on daily energy expenditure conducted off northern Norway and Svalbard (Blix and Folkow, 1995). The limited depth information available (from Figure 2 in Blix and Folkow, 1995) was representative of a 75-min diving sequence where the whale was apparently searching for capelin, then foraging, then searching for another school of capelin. Search dives were mostly to ~20 m, while foraging dives were to 65 m. **Based on this very limited depth information, rough estimates for % of time at depth are as follows: 53% at <20 m and 47% at 21-65 m.**

G.4.7 Unidentified Balaenopterid, *Balaenoptera* sp.

Balaenopterid whale sightings that could not be identified to individual species were analyzed as a species group, unidentified balaenopterids. **The density for this combined species group from the 2007 vessel survey effort was 0.00012/km^2 (SRS-Parsons et al., 2007), which is applicable year round.**

The depth distribution for fin whales will be extrapolated to this species group. Therefore, **40% at <50m, 20% at 50-225 m and 40% at >225 m.**

G.4.8 Humpback whale, *Megaptera novaeangliae*—Regular

Humpback whales are found in all oceans, in both coastal and continental waters as well as near seamounts and deep water during migration (Reeves et al., 2002). Some populations have been extensively studied (e.g., Hawaii, Alaska, Caribbean), and details about migratory timing, feeding and breeding areas are fairly well known. Humpbacks are highly migratory, feeding in summer at mid and high latitudes and calving and breeding in winter in tropical or subtropical waters. Humpback whales are regular visitors to the Marianas region (DoN , 2005). Distribution and abundance of humpbacks in this area is still largely unknown, but they are not expected in the area from June-September. They were observed only once during the 2007 vessel survey, but were the second most frequent acoustically detected mysticete (SRS-Parsons et al., 2007). The acoustic data (singing males) may indicate that the area around Saipan is an active breeding site. Density for humpback whales in the ETP ranged from 0.0001-0.0069/km^2 (Ferguson and Barlow, 2003) and 0.2186/km^2 for Hawaii inshore waters (during peak breeding season; Mobley et al., 2001). The Hawaii breeding population is well studied regarding population size and timing, and there is no indication that the Marianas represent a similar size breeding area. Therefore, **the highest density (0.0069/km^2) reported for the ETP will be used for this area.**

Humpback whales feed on pelagic schooling euphausiids and small fish including capelin, herring and mackerel (Clapham, 2002). Diet composition analyzed by Pauly et al. (1998) indicated that most of diet (55%) was large zooplankton with 15% composed of small pelagics and 30% miscellaneous fishes. Like other large mysticetes, humpback whales are a "lunge feeder" taking advantage of dense prey patches and engulfing as much food as possible in a single gulp. They also blow nets, or curtains, of bubbles around or below prey patches to concentrate the prey in one area, then lunge with mouths open through the middle. Dives appear to be closely correlated with the depths of prey patches, which vary from location to location. In the north Pacific, most dives were of fairly short duration (<4 min) with the deepest dive to 148 m (southeast Alaska; Dolphin, 1987a), while whales observed feeding on Stellwagen Bank in the North Atlantic dove to <40 m (Hain et al., 1995). Depth distribution data collected at a feeding area in Greenland resulted in the following estimation of depth distribution: 37% of time at <4 m, 25% at 4-20 m, 7% at 21-35m, 4% at 36-50 m, 6% at 51-100 m, 7% at 101-150 m, 8% at 151-200 m, 6% at 201-300 m, and <1% at >300 m (Dietz et al., 2002). The area near the Marianas may be part of a humpback whale breeding area, however, so non-feeding depth distributions collected by Baird et al. (2000a) in Hawaii are likely more appropriate: **40% of time in 0-10 m, 27% in 11-20 m, 12% in 21-30**

m, 4% in 31-40 m, 3% in 41-50 m, 2% in 51-60 m, 2% in 61-70 m, 2% in 71-80 m, 2% in 81-90 m, 2% in 91-100 m, 1% in 101-110 m, 1% in 111-120 m, 1% in 121-130 m, 1% in 131-140 m, and <1% in <140 m depth.

G.4.9 North Pacific right whale, Eubalaena japonica—Rare

North Pacific right whales range across the northern Pacific, from the Bering Sea south to Japan in the west and California in the east. They occur mostly in coastal and shelf waters but have been sighted well offshore (Reeves et al., 2002). Despite international protection, the species has not recovered and remains one of the rarest of all cetaceans. Their distribution range may include the Marianas, but **there is no information on population size nor is there any density applicable to the area.**

G.5 ODONTOCETES

G.5.1 Sperm whale, *Physeter catodon*—Regular

Sperm whales are most often found in deep water, near submarine canyons, and along the edges of banks and over continental slopes (Reeves et al., 2002). Adult males range farther north than females and juvenile males which tend to inhabit waters >1,000 m deep and north to 50°N in the north Pacific. Sperm whales were the most frequently sighted mysticete during the 2007 vessel survey in the Marianas (SRS-Parsons et al., 2007)**. Density was calculated as 0.00123/km^2, which is applicable year round.**

Unlike other cetaceans, there is a preponderance of dive information for this species, most likely because it is the deepest diver of all cetacean species so generates a lot of interest. Sperm whales feed on large and medium-sized squid, octopus, rays and sharks, on or near the ocean floor. Diet composition analyzed by Pauly et al. (1998) indicated that most of diet (60%) were large squids with the remaining composition including benthic invertebrates, small squids, small pelagics, mesopelagics, and miscellaneous fishes. Some evidence suggests that sperm whales do not always dive to the bottom of the sea floor (likely if food is elsewhere in the water column), but that they do generally feed at the bottom of the dive. Davis et al. (2007) report that dive-depths (100-500 m) of sperm whales in the Gulf of California overlapped with depth distributions (200-400 m) of jumbo squid, based on data from satellite-linked dive recorders placed on both species, particularly during daytime hours. Their research also showed that sperm whales foraged throughout a 24-hour period, and that they rarely dove to the sea floor bottom (>1,000 m). The most consistent sperm whale dive type is U-shaped, whereby the whale makes a rapid descent to the bottom of the dive, forages at various velocities while at depth (likely while chasing prey) and then ascends rapidly to the surface. Amano and Yoshioka (2003) attached a tag to a female sperm whale near Japan in an area where water depth was 1,000-1,500m. Based on values in Table 1 (in Amano and Yoskioka, 2003) for dives with active bottom periods, the total mean dive sequence was 45.9 min (mean surface time plus dive duration). Mean post dive surface time divided by total time (8.5/45.9), plus time at surface between deep dive sequences yields a percentage of time at the surface (<10 m) of 31%. Mean bottom time divided by total time (17.5/45.9) and adjusted to include the % of time at the surface between dives, yields a percentage of time at the bottom of the dive (in this case >800 m as the mean maximum depth was 840 m) of 34%. Total time in the water column descending or ascending equals duration of dive minus bottom time (37.4-17.5) or ~20 minutes. Assuming a fairly equal descent and ascent rate (as shown in the table) and a fairly consistent descent/ascent rate over depth, we assume 10 minutes each for descent and ascent and equal amounts of time in each depth gradient in either direction. Therefore, 0-200 m = 2.5 minutes one direction (which correlates well with the descent/ascent rates provided) and therefore 5 minutes for both directions. Same for 201-400 m, 401-600 m and 601-800 m. **Therefore, the depth distribution for sperm whales based on information in the Amano paper is: 31% in <10 m, 8% in 10-200 m, 9% in 201-400 m, 9% in 401-600 m, 9% in 601-800 m and 34% in >800 m.** The percentages derived above from data in Amano and Yoshioka (2003) are in fairly close agreement with those derived from Table 1 in Watwood et al. (2006) for sperm whales in the Ligurian Sea, Atlantic Ocean and Gulf of Mexico.

G.5.2 Pygmy (*Kogia breviceps)* and Dwarf *(K. sima)* sperm whales—Regular

Pygmy and dwarf sperm whales are very cryptic at-sea, and generally difficult to see even under the best survey conditions. No *Kogia* were seen during the 2007 vessel survey (SRS-Parsons et al., 2007), when survey conditions were far less than optimal. They are considered regular visitors to the area (DoN, 2005). The distribution of *Kogia* sp. is generally temperate to tropical and probably seaward of the continental shelf (Reeves et al., 2002). Density for dwarf and pygmy sperm whales in the ETP ranged from 0.0015-0.0269/km^2 (Ferguson and Barlow, 2003) and 0.0078/km^2 for Hawaii offshore (Barlow, 2006). **The offshore Hawaii density (0.0078/km^2) is likely more indicative for this species group in the Marianas than densities from the ETP, and will be used for this analysis.**

There are no depth distribution data for this species. An attempt to record dive information on a rehabbed pygmy sperm whale failed when the TDR package was never recovered (Scott et al., 2001). Prey preference, based on stomach content analysis from Atlantic Canada (McAlpine et al., 1997) and New Zealand (Beatson, 2007), appears to be mid and deep water cephalopods, crustaceans and fish. Diet composition analyzed by Pauly et al. (1998) indicated that most of diet (75-80%) were small and large squids with the remaining composition including benthic invertebrates, mesopelagics and miscellaneous fishes. There is some evidence that they may use suction feeding and feed at or near the bottom. They may also take advantage of prey undergoing vertical migrations to shallower waters at night (Beatson, 2007). In lieu of any other information, Blainville’s beaked whale depth distribution data will be extrapolated to pygmy sperm whales as the two species appear to have similar prey preferences and are closer in size than either is to sperm or Cuvier’s beaked whales. Blainville’s undertakes shallower non-foraging dives in-between deep foraging dives. **Blainville’s beaked whale depth distribution data, taken from Tyack et al. (2006) and summarized in greater depth later in this document is: 26% at <2 m, 41% at 2-71 m, 2% at 72-200 m, 4% at 201-400 m, 4% at 401-600 m, 4% at 601-835 m and 19% at >838 m.**

G.5.3 Cuvier’s beaked whale, *Ziphius cavirostris*—Regular

Cuvier’s beaked whale has the widest distribution of all beaked whales, and occurs in all oceans. It is most often found in deep offshore waters, and appears to prefer slope waters with steep depth gradients (Heyning, 2002). As with most beaked whales, Cuvier’s are fairly cryptic at-sea and therefore difficult to sight and identify. Cuvier’s were not seen during the 2007 vessel cruise (acoustic detections were not possible due to the limitations of the system at higher frequencies), but are considered regular visitors to the Marianas area based on habitat (DoN, 2005). Density for Cuvier’s beaked whales in the ETP ranged from 0.003-0.038/km^2 (Ferguson and Barlow, 2003) and 0.0052/km^2 for offshore Hawaii (Barlow, 2006). **The offshore Hawaii density (0.0052/km^2) is likely more indicative for this species in the Marianas than densities from the ETP, and will be used for this analysis.**

Cuvier’s feed on meso-pelagic or deep water benthic organisms, particularly squid (Heyning, 2002). Stomach content analysis indicates that they take advantage of a larger range of prey species than do other deep divers (e.g., Santos et al., 2001; Blanco and Raga, 2000). Cuvier’s, like other beaked whales, are likely suction feeders based on the relative lack of teeth and enlarged hyoid bone and tongue muscles. Foraging dive patterns appear to be U-shaped, although inter-ventilation dives are shallower and have a parabolic shape (Baird et al., 2006a). Depth distribution studies in Hawaii (Baird et al., 2005a; Baird et al., 2006a) found that Cuvier’s undertook three or four different types of dives, including intermediate (to depths of 292-568 m), deep (>1,000 m) and short-inter-ventilation (within 2-3 m of surface); this study was of a single animal. Studies in the Ligurian Sea indicated that Cuvier’s beaked whales dived to >1,000 m and usually started “clicking” (actively searching for prey) around 475 m (Johnson et al., 2004; Soto et al., 2006). Clicking continued at depths and ceased once ascent to the surface began, indicating active foraging at depth. In both locations, Cuvier’s spent more time in deeper water than did Blainville's beaked whale, although maximum dive depths were similar. There was no significant difference between day and night diving indicating that preferred prey likely does not undergo vertical migrations.

Dive information for Cuvier's was collected in the Ligurian Sea (Mediterranean) via DTAGs on a total of seven animals (Tyack et al., 2006) and, despite the geographic difference and the author's cautions about the limits of the data set, the Ligurian Sea dataset represents a more complete snapshot than that from Hawaii (Baird et al., 2006a). Cuvier's conducted two types of dives – U-shaped deep foraging dives (DFD) and shallow duration dives. Dive cycle commenced at the start of a DFD and ended at the start of the next DFD, and included shallow duration dives made in between DFD.

Mean length of dive cycle = 121.4 min (mean DFD plus mean Inter-deep dive interval)

Number of DFD recorded = 28

Mean DFD depth = 1070 m (range 689-1888 m)

Mean length DFD = 58.0 min

Mean Vocal phase duration = 32.8 min

Mean inter-deep dive interval = 63.4 min

Mean shallow duration dive = 221 m (range 22-425 m)

Mean # shallow duration dives per cycle = 2 (range 0-7)

Mean length of shallow duration dives = 15.2 min

Total time at surface (0-2 m) was calculated by subtracting the mean length of DFD and two shallow duration dives from the total dive cycle (121.4 - 58.0 – 30.4 = 33 min). Total time at deepest depth was taken from the Vocal phase duration time, as echolocation clicks generally commenced when animals were deepest, and was 32.8 min. The amount of time spent descending and ascending on DFDs was calculated by subtracting the mean Vocal phase duration time from the mean total DFD (58.0 - 32.8 = 25.2 min) and then dividing by five (# of 200 m depth categories between surface and 1070 m) which equals ~five min per 200 m. The five-minute value was applied to each 200 m depth category from 400-1070 m; for the 2-220 m category, the mean length of shallow duration dives was added to the time for descent/ascent (30.4 + 5 = 35.4 min). **Therefore, the depth distribution for Cuvier's beaked whales based on best available information from Tyack et al. (2006) is: 27% at <2 m, 29% at 2-220 m, 4% at 221-400 m, 4% at 401-600 m, 4% at 601-800 m, 5% at 801-1070 m and 27% in >1070 m.**

G.5.4 Blainville's beaked whale, *Mesoplodon densirostris*—Regular

Blainville's are distributed circumglobally in tropical and warm temperate waters (Pitman, 2002b). Very little is known about the behavior of this species, as they are cryptic and difficult to sight at-sea. Blainville's were not seen during the 2007 vessel cruise (acoustic detections were not possible due to the limitations of the system at higher frequencies), but are considered regular visitors to the Marianas area based on habitat (DoN, 2005). Density for Blainville's beaked whales in the ETP ranged from 0.0005-0.0013/km^2 (Ferguson and Barlow, 2003) and 0.0009/km^2 for offshore Hawaii (Barlow, 2006). **The offshore Hawaii density (0.0009/km^2) is likely more indicative for this species in the Marianas than densities from the ETP, and will be used for this analysis.**

This species feeds primarily on mesopelagic squid and some fish, with most prey likely caught at >200 m (Pitman, 2002b). Like other beaked whales, they are believed to be suction feeders. Dive information has been collected on Blainville's beaked whales in Hawaii (Baird et al., 2006a; 2005a) and the Canary Islands (Tyack et al., 2006). Dive information for Blainville's collected in the Canary Islands via DTAGs on a total of eight animals (Tyack et al., 2006) represents a more complete snapshot than that from Hawaii (Baird et al., 2006a). Blainville's conducted two types of dives – U-shaped deep foraging dives (DFD) and shallow duration dives. Dive cycle commenced at the start of a DFD and ended at the start of the next DFD, and included shallow duration dives made in between DFD.

Mean length of dive cycle = 138.8 min (mean DFD plus mean Inter-deep dive interval)

Number of DFD recorded = 16

Mean DFD depth = 835 m (range 640-1251 m)

Mean length DFD = 46.5 min

Mean Vocal phase duration = 26.4 min

Mean inter-deep dive interval = 92.3 min

Mean shallow duration dive = 71 m (range 20-240)

Mean # shallow duration dives per cycle = 6 (range 1-12)

Mean length of shallow duration dives = 9.3 min

Total time at surface (0-2 m) was calculated by subtracting the mean length of DFD and six shallow duration dives from the total dive cycle (138.8 – 46.5 – 55.8 = 36.5 min). Total time at mean deepest depth was taken from the Vocal phase duration time, as echolocation clicks generally commenced when animals were deepest, and was 26.4 min. The amount of time spent descending and ascending on DFDs was calculated by subtracting the mean Vocal phase duration time from the mean total DFD (46.5 – 26.4 = 20.1 min) and then dividing by 12 (# of 70 m depth categories between surface and 838 m), which equals 1.7 min per 70 m. The 1.7 min value was applied to each 70 m depth category from 72-838 m; for the 2-71 m category, the mean length of shallow duration dives was added to the time for descent/ascent (55.8 + 1.7 = 57.5 min). **Therefore, the depth distribution for Blainville's beaked whales (and applicable to *Mesoplodon* sp) based on best available information from Tyack et al. (2006) is: 26% at <2 m, 41% in 2-71 m, 2% at 72-200 m, 4% at 201-400 m, 4% at 401-600 m, 4% at 601-835 m, and 19% at >835 m.**

G.5.5 Ginkgo-toothed beaked whale, *Mesoplodon ginkgodens*—Rare

Ginkgo-toothed beaked whales are distributed in warm temperate and tropical waters of the Pacific and Indian oceans (Pitman, 2002b). They were not seen during the 2007 vessel cruise (acoustic detections were not possible due to the limitations of the system at higher frequencies), but are considered rare visitors to the Marianas area based on habitat (DoN, 2005). Density for ginkgo-toothed beaked whales in the ETP ranged from 0.0005-0.0064/km^2 (Ferguson and Barlow, 2003). Due to the rare status and complete lack of sightings in the Marianas, **the lowest density (0.0005/ km^2) reported for the ETP will be used for this area and is applicable year round.**

There are no depth distribution data for this species. Like other *Mesoplodon*, they are believed to feed primarily on mesopelagic squid and some fish, with most prey likely caught at >200 m, and they are probably suction feeders. Depth distribution for *Mesoplodon densirostris* will be extrapolated to this species: **26% at <2 m, 41% in 2-71 m, 2% at 72-200 m, 4% at 201-400 m, 4% at 401-600 m, 4% at 601-835 m, and 19% at >835 m.**

G.5.6 Hubbs' beaked whale, *Mesoplodon carlhubbsi*—Extralimital

Hubb's beaked whales are known only from temperate waters of the North Pacific, mainly along the west coast of North America (Pitman, 2002b), and there are no known occurrences in the Marianas. Likely occurrence is considered extralimital (DoN, 2005) due to it known preference for colder water. **There is no density**.

G.5.7 Longman's beaked whale, *Indopacetus pacificus*—Regular

Longmans's beaked whale is found in offshore deep waters of the continental slope (200-2,000 m) or deeper (Pitman, 2002a). Very little is known about the behavior of this species, as they are cryptic and difficult to sight at-sea. Longman's were not seen during the 2007 vessel cruise (acoustic detections were not possible due to the limitations of the system at higher frequencies), but are considered regular visitors to the Marianas area based on habitat (DoN, 2005). Density for Longman's beaked whales in the ETP ranged from 0.0002-0.003km^2 (Ferguson and Barlow, 2003) and 0.0003/km^2 for offshore Hawaii (Barlow, 2006). **The offshore Hawaii density (0.0003/km^2) is likely more indicative for this species in the Marianas than densities from the ETP, and will be used for this analysis.**

Beaked whales feed primarily on mesopelagic squid and some fish, with most prey likely caught at >200 m (Pitman, 2002b). Most are believed to be suction feeders. There are no depth distribution data for Longman's beaked whales; therefore the depth distribution for Cuvier's beaked whales will be extrapolated to Longman's: **27% at <2 m, 29% at 2-220 m, 4% at 221-400 m, 4% at 401-600 m, 4% at 601-800 m, 5% at 801-1070 m and 27% in >1070 m.**

G.5.8 Killer whale, *Orcinus orca*—Regular

Killer whales are one of the most widely distributed mammal species in the world and are found in all oceans (Ford, 2002). There were no sightings during the 2007 vessel survey (SRS-Parsons et al., 2007), but they are considered a regular visitor to the Marianas region (DoN, 2005). Density for killer whales in the ETP ranged from 0.0001-0.0004km^2 (Ferguson and Barlow, 2003) and 0.000/km^2 for offshore Hawaii (Barlow, 2006). **The offshore Hawaii density (0.0002/km^2) is likely more indicative for this species in the Marianas than densities from the ETP, and will be used for this analysis.**

Killer whales feed on a variety of prey, including salmon, herring, cod, tuna and cephalopods (Ford, 2002). "Transient" stocks of killer whales feed on other marine mammals, including other whales, pinnipeds (e.g., London, 2006) and sea otters (e.g., Estes et al., 1998). Diving studies on killer whales have been undertaken mainly on "resident" (fish-eating) killer whales in Puget Sound and may not be applicable across all populations of killer whales. Diving is usually related to foraging, and mammal-eating killer whales may display different dive patterns. Killer whales in one study (Baird et al., 2005b) dove as deep as 264 m, and males dove more frequently and more often to depths >100 m than females, with fewer deep dives at night. Dives to deeper depths were often characterized by velocity bursts which may be associated with foraging or social activities. Using best available data from Baird et al. (2003a), it would appear that **killer whales spend ~4% of time at depths >30 m and 96% of time at depths 0-30 m**.

G.5.9 False killer whale, *Pseudorca crassidens*—Regular

False killer whales are found in tropical to warm temperate waters, with well known populations near Japan and in the eastern tropical Pacific (Baird, 2002a). They are mainly pelagic but will occur close to shore near oceanic islands. False killer whales were sighted during the 2007 vessel survey (SRS-Parsons et al., 2007), and detected acoustically. **Density was calculated as 0.00111/km^2 (SRS-Parsons et al., 2007), which is applicable year round.**

False killer whales feed on oceanic fish and squid, and have been known to prey on smaller marine mammals (Baird, 2002a; Koen Alonso et al., 1999; Santos and Haimovici, 2001). The only study conducted on diving of false killer whales in Hawaii has not been published in any detail (Ligon and Baird, 2001), but an abstract provide limited information. False killer whales did not dive deep and instead recorded maximum dives of 22, 52 and 53 m in near-shore Hawaiian waters**. In lieu of other information, the depth distribution for killer whales will be extrapolated to this species: 4% of time at depths >30 m and 96% of time at depths 0-30 m.**

G.5.10 Pygmy killer whale, *Feresa attenuata*—Regular

Pygmy killer whales are known primarily from tropical to sub-tropical waters (Donahue and Perryman, 2002). They were sighted during the 2007 vessel survey (SRS-Parsons et al., 2007) and d**ensity was calculated as 0.00014/km^2 (SRS-Parsons et al., 2007), which is applicable year round.**

Pygmy killer whales feed on cephalopods, small fish and small delphinids (Donohue and Perryman, 2002; Santos and Haimovici, 2001). There have not been any studies of diving patterns specific to this species. **In lieu of other information, the depth distribution for killer whales will be extrapolated to this species: 4% of time at depths >30 m and 96% of time at depths 0-30 m.**

G.5.11 Short-finned pilot whale, *Globicephala macrorhynchus*—Regular

This species is known from tropical and warm temperate waters, and is found primarily near continental shelf breaks, slope waters and areas of high topographic relief (Olson and Reilly, 2002). Short-finned pilot whales were sighted during the 2007 vessel survey (SRS-Parsons et al., 2007), and detected acoustically. **Density was calculated as 0.00159/km^2 (SRS-Parsons et al., 2007), which is applicable year round.**

Short-finned pilot whales feed on squid and fish. Diet composition analyzed by Pauly et al. (1998) indicated that most of diet (60%) was small and large squids with the remaining composition including small pelagics, mesopelagics and miscellaneous fishes. Stomach content analysis of pilot whales in the southern California Bight consisted entirely of cephalopod remains (Sinclair, 1992). The most common prey item identified by Sinclair (1992) was *Loligo opalescens*, which has been documented in spawning concentrations at depths of 20-55 m. Stomach content analysis from the closely related long-finned pilot whale (*Globicephala melas*) from the U.S mid-Atlantic coast demonstrated preference for cephalopods as well as a relatively high diversity of prey species taken (Gannon et al., 1997). Stomach content analysis from *G. melas* off New Zealand did not show the same diversity of prey (Beatson et al., 2007) which indicates that pilot whales may differ significantly in prey selection based on geographic location. The only study conducted on short-finned pilot whales in Hawaii has not been published in any detail (Baird et al., 2003b), but an abstract indicated that there were significant differences between day and night diving; dives of >100m were far more frequent at night, likely to take advantage of vertically-migrating prey; night dives regularly went to 300-500 m. Deepest dives were during the day, however, perhaps because prey was deeper. A diving study on *G. melas* also showed marked differences in daytime and nighttime diving in studies in the Ligurian Sea (Baird et al., 2002b), but there was no information on percentage of time at various depth categories. A study following two rehabilitated and released long-finned pilot whales provides a breakdown of percentage of time at depth distribution for two whales (Nawojchik et al., 2003), although this data may be skewed due to the unique situation. **Heide-Jorgensen et al. (2002) studied diving behavior of long-finned pilot whales near the Faroe Islands in the north Atlantic. Most diving activity occurred at depth of less than 36 m and >90% of dives were within 12-17 m. Based on this information, the following are estimates of time at depth for both species of pilot whale: 60% at <7 m, 36% at 7-17 m and 4% at 18-828 m.**

G.5.12 Risso's dolphin, *Grampus griseus*—Regular

This species is known from tropical and warm temperate oceans, primarily in waters with surface temperatures between 50 and 82˚F (Reeves et al., 2002). They are mostly found in water depths from 400-1,000 m but are also known from the continental shelf. Risso's dolphin is considered a regular visitor to the Marianas region (DoN, 2005), although none were seen during the 2007 vessel survey (SRS-Parsons et al., 2007). Density for Risso's dolphins in the ETP ranged from 0.0005 to 0.3358/km^2 (Ferguson and Barlow, 2003) and 0.0106 for the western Pacific (Miyashita, 1993). **The western Pacific density (0.0106/km^2) is likely more indicative for this species in the Marianas than densities from the ETP, and will be used for this analysis.**

There are no depth distribution data for this species. They are primarily squid eaters and feeding is presumed to take place at night. A study undertaken in the Gulf of Mexico demonstrated that Risso's are distributed non-uniformly with respect to depth and depth gradient (Baumgartner, 1997), utilizing mainly the steep sections of upper continental slope bounded by the 350 m and 975 m isobaths. Those data agree closely with Blanco et al. (2006), who collected stomach samples from stranded Risso's dolphins in the western Mediterranean. Their results indicated that, based on prey items, Risso's fed on the middle slope at depths ranging from 600-800 m. Stomach content analysis from three animals elsewhere in the Mediterranean indicated that Risso's fed on species that showed greater vertical migrations than those ingested by striped dolphins (Ozturk et al., 2007). **In lieu of depth distribution information or information on shape of dives, the following are rough estimates of time at depth based on habitat and prey distribution: 50% at <50 m, 15% at 51-200 m, 15% at 201-400 m, 10% at 401-600 m and 10% at >600 m.**

G.5.13 Melon-headed whale, *Peponocephala electra*—Regular

Melon-headed whales are found worldwide in deep, offshore tropical and subtropical waters (Perrin, 2002c). They were sighted during the 2007 vessel survey (SRS-Parsons et al., 2007), and detected acoustically. **Density was calculated as 0.00428/km^2 (SRS-Parsons et al., 2007), which is applicable year round.**

Melon-headed whales feed on squid, fish and occasionally crustaceans in the water column (Perrin, 2002c). Their prey is known to occur at depths to 1,500 m, although there is no direct evidence that the whales feed to that depth. Stomach content analysis suggests that they feed on prey similar to Fraser's dolphins (Jefferson and Barros, 1997). Diet composition analyzed by Pauly et al. (1998) indicated that most of diet (70%) was small and large squids with the remaining composition including small pelagics, mesopelagics and miscellaneous fishes. There is not depth distribution data for this species; the depth distribution for Fraser's dolphins will be extrapolated to melon-headed whales: **Daytime, 100% at 0-50 m; Nighttime, 100% at 0-700 m.**

G.5.14 Fraser's dolphin, *Lagenodelphis hosei*—Regular

Fraser's dolphins are distributed in tropical waters of all oceans, between 30°N and 30°S (Dolar, 2002). Distribution appears to be oceanic (>200 m) in most areas. Fraser's dolphin is considered a regular visitor to the Marianas region (DoN, 2005), although none were seen during the 2007 vessel survey (SRS-Parsons et al., 2007). Density for Fraser's dolphins in the ETP ranged from 0.005 to 0.1525/km^2 (Ferguson and Barlow, 2003) and 0.0069 for Hawaii offshore (Barlow, 2006). **The offshore Hawaii density (0.0069/km^2) is likely more indicative for this species in the Marianas than densities from the ETP, and will be used for this analysis.**

Fraser's dolphins prey on mesopelagic fish, crustaceans and cephalopods, and take advantage of vertically migrating prey at night (Dolar, 2002). Stomach contents from dolphins in the Sulu Sea, Philippines, contained crustaceans, cephalopods and myctophid fish (Dolar et al., 2003). Fraser's dolphins took larger prey than spinner dolphins feeding in the same area, and likely foraged to depths of at least 600 m, based on prey composition and behavior. This species has also been observed herding fish and feeding at the surface, taking short dives and surfacing in the middle of the herded fish school (Watkins et al., 1994). **Based on this very limited information, the following are very rough order estimates of time at depth: Daytime, 100% at 0-50 m; Nighttime, 100% at 0-700 m.**

G.5.15 Common bottlenose dolphin, *Tursiops truncatus*—Regular

Bottlenose dolphins are distributed in all oceans from temperate to tropical latitudes. Bottlenose dolphins were sighted during the 2007 vessel survey (SRS-Parsons et al., 2007), and detected acoustically. **Density was calculated as 0.00021/km^2 (SRS-Parsons et al., 2007), which is applicable year round.**

Bottlenose dolphins feed on a large variety of fish and squid (Wells and Scott, 2002). Diet composition analyzed by Pauly et al. (1998) indicated that most of diet (60%) was miscellaneous fishes with the remaining composition including small and large squids and small pelagics. Several studies on bottlenose dolphin feeding preferences illustrate variation at different geographic locations. Rossbach and Herzing (1997) observed bottlenose dolphins in the Bahamas feeding on the bottom (7-13 m) by orienting their heads down and moving from side to side, and several species regularly fed on prey along the sea floor (Wells and Scott, 2002). Corkeron and Martin (2004) reported on two dolphins that spent 66% percent of time in top 5 m of water surface; maximum dive depth was greater than 150 m and there was no apparent diurnal pattern. Stomach content analysis from Brazil indicated that small and medium-sized cephalopods were primary prey of animals found in shelf regions (Santos and Haimovici, 2001), while off Tasmania, bottlenose dolphin prey consisted of oceanic species that were known to commonly occur on the shelf as well (Gales et al. 1992). Klatsky et al. (2007) reported on dive data of dolphins tagged at the Bermuda Pedestal in the north Atlantic. Dolphins dove to at least 492 m depth, with deep dives (>100 m) occurring exclusively at night. Dives during the day were to shallower than at night, with 90% of all dives to within 50 m of the surface. Based on data presented in Klatsky et al. (2007; Figure 3), the **following depth distribution has been estimated for bottlenose dolphins: Daytime: 96% at <50 m, 4% at >50 m; Nighttime: 51% at <50 m, 8% at 50-100 m, 19% at 101-250 m, 13% at 251-450 m and 9% at >450 m. Data on time spent at the surface were not published; therefore surface time was included in the least shallow depth category published.**

G.5.16 Indo-Pacific bottlenose dolphin, *Tursiops aduncus*—Extralimital

The Indo-Pacific bottlenose dolphin is distributed in coastal waters of the Indian Ocean and western Pacific Ocean, and is not generally associated with offshore islands (Wells and Scott, 2002). Their occurrence in the Marianas would be considered extralimital and **there is no density.**

G.5.17 Rough-toothed dolphin, *Steno bredanensis*—Regular

Rough-toothed dolphins are distributed in warm temperate to tropical waters of all oceans. They were sighted during the 2007 vessel survey (SRS-Parsons et al., 2007), and detected acoustically. **Density was calculated as 0.00029/km^2 (SRS-Parsons et al., 2007), which is applicable year round.**

Rough-toothed dolphins feed on fish and cephalopods, both oceanic and coastal species (Jefferson, 2002b). Diet composition analyzed by Pauly et al. (1998) indicated that the diet was variable including miscellaneous fishes, small pelagics, small and large squids, and benthic invertebrates. Based on anatomy, they appear to be adapted to deep diving (Miyazaki and Perrin, 1994), although the maximum record dive is to only 70 m (Jefferson, 2002b). There have been no depth distribution studies done on this species. In lieu of other information, **the following is a rough estimation of time at depth: 100% at 0-70 m.**

G.5.18 Bottlenose/rough-toothed dolphin, *Tursiops/Steno*—Regular

Sightings of dolphins during the 2007 vessel survey that could not be identified to species, but which were positively identified as either bottlenose or rough-toothed dolphins, were analyzed as this species group. **Density was calculated as 0.00009/km^2 (SRS-Parsons et al., 2007), which is applicable year round.**

The depth distribution data for rough-toothed dolphins will be used for this species group as it represents a more conservative data set: **100% at 0-70 m.**

G.5.19 Short-beaked common dolphin, *Delphinus delphis*—Rare

Short-beaked common dolphins are found in continental shelf waters of the Atlantic and Pacific, as well as pelagic waters of the eastern tropical Pacific and Hawaii (Reeves et al., 2002; Perrin, 2002b). Common dolphins were not seen or detected acoustically during surveys in 2007 (SRS-Parsons et al., 2007). Density for common dolphins in the ETP ranged from 0.0021 to 1.9112/km^2 (Ferguson and Barlow, 2003). Due to the rare status and complete lack of sightings in the Marianas, **the lowest density (0.0021/ km^2) reported for the ETP will be used for this area.**

Common dolphins feed on small schooling fish as well as squid and crustaceans, and varies on habitat and location. They appear to take advantage of the deep scattering layer at dusk and during early night-time hours, when the layer migrates closer to the water surface, as several prey species identified from stomach contents are known to vertically migrate (e.g., Ohizumi et al., 1998; Pusineri et al., 2007). Perrin (2002b) reports foraging dives to 200 m, but there have been no detailed studies of diving behavior**. Based on this limited information, depth distribution is estimated as: 100% at 0-200m.**

G.5.20 Striped dolphin, *Stenella coeruleoalba*—Regular

Striped dolphins are distributed in tropical and warm temperate waters of all oceans. They are generally found over the continental slope out to oceanic waters, particularly in areas of upwelling (Archer, 2002). They were sighted during the 2007 vessel survey (SRS-Parsons et al., 2007), and detected acoustically. **Density was calculated as 0.00616/km^2 (SRS-Parsons et al., 2007), which is applicable year round.**

Striped dolphins feed on pelagic fish and squid and may dive during feeding to depths exceeding 200 m (Archer, 2002). Diet composition analyzed by Pauly et al. (1998) indicated that the diet was variable including mesopelagics, miscellaneous fishes, small and large squids, small pelagics, and benthic invertebrates. However, studies are rare on this species. Stomach content remains from three dolphins in the Mediterranean included several species of cephalopod as well as some fish, and suggested that striped dolphins may not feed quite as deep as Risso's dolphins (Ozturk et al., 2007). They appear to be opportunistic feeders, as stomach samples from the Ligurian Sea included cephalopods, crustaceans and bony fishes (Wurtz and Marrale, 1993). There is some evidence that striped dolphins feed at night to take advantage of vertical migrations of the deep scattering layer. In lieu of other information, pantropical spotted dolphin depth distribution data will be extrapolated to striped dolphins. One study on pantropical spotted dolphins in Hawaii contains dive information (Baird et al., 2001a). The biggest differences recorded were in the increase in dive activity at night. During the day, 89% of time was spent within 0-10 m, most of the rest of the time was 10-50 m, and the deepest dive was to 122 m. At night, only 59% of time was spent from 0-10 m and the deepest dive was to 213 m; dives were especially pronounced at dusk. For activities conducted during daytime-only, **the depth distribution would be 89% at 0-10 m and 11% at 11-50 m, with <1% at 51-122 m.** For activities conducted over a 24-hour period, the depth distribution needs to be modified to reflect less time at surface and deeper depth dives; **80% at 0-10 m, 8% at 11-20 m, 2% at 21-30 m, 2% at 31-40 m, 2% at 41-50 m, and 6% at 51-213 m.**

G.5.21 Spinner dolphin, *Stenella longirostris*—Regular

Spinner dolphins are found in tropical and subtropical waters of all oceans (Perrin, 2002d). They were sighted during the 2007 vessel survey (SRS-Parsons et al., 2007), and detected acoustically. **Density was calculated as 0.00314/km^2 (SRS-Parsons et al., 2007), which is applicable year round.**

Spinner dolphins feed on small mesopelagic fishes, and likely feed at night (Perrin, 2002d; Benoit-Bird and Au, 2003). Diet composition analyzed by Pauly et al. (1998) indicated a diet of mesopelagics, small and large squids and miscellaneous fishes. Stomach content analysis of spinner dolphins collected in the Sulu Sea, Philippines, indicated that they fed on mesopelagic crustaceans, cephalopods and fish that undertake vertical migrations to ~250 m (Dolar et al., 2003). There was also evidence that they preyed on non-vertical migrating species found at ~400 m, and that they likely did not have the same foraging range as Fraser's dolphins in the same area (to 600 m). Studies on spinner dolphins in Hawaii have been carried out using active acoustics (fish-finders) (Benoit-Bird and Au, 2003). These studies show an extremely close association between spinner dolphins and their prey (small, mesopelagic fishes). Mean depth of spinner dolphins was always within 10 m of the depth of the highest prey density. These studies have been carried out exclusively at night, as stomach content analysis indicates that spinners feed almost exclusively at night when the deep scattering layer moves toward the surface bringing potential prey into relatively shallower (0-400 m) waters. Prey distribution during the day is estimated at 400-700 m. **Based on these data, the following are very rough order estimates of time at depth: Daytime: 100% at 0-50 m; Nighttime: 100% at 0-400 m.**

G.5.22 Pantropical spotted dolphin – *Stenella attenuate*—Regular

Pantropical spotted dolphins are distributed worldwide in tropical and subtropical waters, with distribution extending from 40°N to 40°S (Perrin, 2002a). They were sighted during the 2007 vessel survey (SRS-Parsons et al., 2007), and detected acoustically. **Density was calculated as 0.0226/km^2 (SRS-Parsons et al., 2007), which is applicable year round.**

Pantropical spotted dolphins feed on small epipelagic fishes, squids and crustaceans, and may vary their preferred prey seasonally (Perrin, 2002a; Wang et al., 2003). Diet composition analyzed by Pauly et al. (1998) indicated that most of diet (70%) was miscellaneous fishes and small squids with the remaining composition including large squids and small pelagics. Stomach contents of dolphins collected near Taiwan indicated that the distribution of primary prey was 0-200 m at night and >300 m during the day, indicating that these animals feed at night (Wang et al., 2003). One study on this species, conducted in Hawaii, contains dive information (Baird et al., 2001a). The biggest differences recorded were in the increase in dive activity at night. During the day, 89% of time was spent within 0-10 m, most of the rest of the time was 10-50 m, and the deepest dive was to 122 m. At night, only 59% of time was spent from 0-10 m and the deepest dive was to 213 m; dives were especially pronounced at dusk. The following depth distributions are applicable: **Daytime**, **89% at 0-10 m and 11% at 11-50 m, with <1% at 51-122 m; Nighttime, 80% at 0-10 m, 8% at 11-20 m, 2% at 21-30 m, 2% at 31-40 m, 2% at 41-50 m, and 6% at 51-213 m.**

G.5.23 Unidentified delphinid

Any dolphin sighted during the 2007 vessel survey that could not be identified to species was analyzed in the broad category of unidentified delphinid (SRS-Parsons et al., 2007). **Density was calculated as 0.00107/km^2 (SRS-Parsons et al., 2007), which is applicable year round.**

The species with the highest density in the Marianas from the 2007 vessel surveys was the pantropical spotted dolphin so the depth distribution for that species was extrapolated to this species group: **Daytime**, **89% at 0-10 m and 11% at 11-50 m, with <1% at 51-122 m; Nighttime, 80% at 0-10 m, 8% at 11-20 m, 2% at 21-30 m, 2% at 31-40 m, 2% at 41-50 m, and 6% at 51-213 m.**

G.6 CARNIVORES (Pinnipeds)

G.6.1 Hawaiian monk seal, *Monachus schauinslandi*—Extralimital

Monk seals are distributed throughout the Hawaiian Island Archipelago and very occasionally south of the Archipelago at Wake Island, Johnston Atoll and Palmyra Atoll (Gilmartin and Forcada, 2002). Monk seals have never been seen in the Marianas region, and **there is no density**.

G.6.2 Northern elephant seal, *Mirounga angustirostris*—Extralimital

Northern elephant seals are distributed in the northeast Pacific, and have been rarely sighted in Hawaii and Japan (Hindell, 2002). They have never been seen in the Marianas region, and **there is no density**.

G.7 SIRENIAN

G.7.1 Dugong, *Dugong dugong*—Extralimital

Dugongs are distributed in tropical and subtropical coastal and island waters of the Indian and Pacific Oceans (Marsh, 2002). There have been a few extralimital sightings near Guam (DoN, 2005) but Palau (>1,700 km distant) is the closest regular occurrence of this species. **There is no density**.

References

Acevedo-Gutierrez, A, DA Croll and BR Tershy. 2002. High feeding costs limit dive time in the largest whales. *Journal of Experimental Biology* 205: 1747-1753.

Aguilar, A. 2002. Fin whale. Pp. 435-438 In: WF Perrin, B Wursig and JGM Thewissen (eds) *Encyclopedia of Marine Mammals*. Academic Press: San Diego. 1414 pp.

Amano, M and M Yoshioka. 2003. Sperm whale diving behavior monitored using a suction-cup-attached TDR tag. *Marine Ecology Progress Series* 258: 291-295.

Archer II, FI. 2002. Striped dolphin. Pp. 1201-1203 In: WF Perrin, B Wursig and JGM Thewissen (eds) *Encyclopedia of Marine Mammals*. Academic Press: San Diego. 1414 pp.

Archer, II, FI and WF Perrin. 1999. *Stenella coeruleoalba*. Mammalian Species 603:1-9.

Baird, RW. 2002a. False killer whale. Pp 411-412 In: WF Perrin, B Wursig and JGM Thewissen (eds) *Encyclopedia of Marine Mammals*. Academic Press: San Diego. 1414 pp.

Baird, RW, DL Webster, DJ McSweeney, AD Ligon, GS Schorr and J. Barlow. 2006a. Diving behaviour of Cuvier’s (*Ziphius cavirostris*) and Blainville’s (*Mesoplodon densirostris*) beaked whales in Hawai’i. *Canadian Journal of Zoology* 84: 1120-1128.

Baird, RW, DJ McSweeney, C Bane, J Barlow, DR Salden, LK Antoine, R LeDuc and DL Webster. 2006b. Killer whales in Hawaiian waters: information on population identity and feeding habits. *Pacific Science* 60: 523-530.

Baird, RW, DL Webster, DJ McSweeney, AD Ligon, and GS Schorr. 2005a. Diving Behavior and ecology of Cuvier's (*Ziphius cavirostris*) and Blainville's beaked whales (*Mesoplodon densirostris*) in Hawai`i. Report prepared by Cascadia Research Collective for the Southwest Fisheries Science Center. Available from www.cascadiaresearch.org.

Baird, RW, MB Hanson and LM Dill. 2005b. Factors influencing the diving behaviour of fish-eating killer whale: Sex differences and diel and interannual variation in diving rates. *Canadian Journal of Zoology* 83(2):257-267.

Baird, RW, MB Hanson, EE Ashe, MR Heithaus and GJ Marshall. 2003a. Studies of foraging in "southern resident" killer whales during July 2002: dive depths, bursts in speed, and the use of a "crittercam" system for examining sub-surface behavior. Report prepared under Order number AB133F-02-SE-1744 for the NMFS-NMML. Available from www.cascadiaresearch.org.

Baird, RW, DJ McSweeney, MR Heithaus and GJ Marshall. 2003b. Short-finned pilot whale diving behavior: deep feeders and day-time socialites. Abstract submitted to the 15th Biennial Conference on the Biology of Marine Mammals, Greensboro, NC, December 2003. Available from www.cascadiaresearch.org.

Baird, RW, JF Borsani, MB Hanson and PL Tyack. 2002b. Diving and night-time behavior of long-finned pilot whales in the Ligurian Sea. *Marine Ecology Progress Series* 237: 301-305.

Baird, RW, AD Ligon, SK Hooker and AM Gorgone. 2001a. Subsurface and nighttime behavior of pantropical spotted dolphins in Hawai'i. *Canadian Journal of Zoology* 79: 988-996.

Baird, RW, AD Ligon and SK Hooker. 2000a. Sub-surface and night-time behavior of humpback whales off Maui, Hawaii: a Preliminary Report. Report under contract #40ABNC050729 from the Hawaiian Islands Humpback Whale National Marine Sanctuary, Kihei, HI to the Hawaii Wildlife Fund, Paia, HI. Available from www.cascadiaresearch.org.

Bannister, JL. 2002. Baleen whales. Pp. 62-72 In: WF Perrin, B Wursig and JGM Thewissen (eds) *Encyclopedia of Marine Mammals*. Academic Press: San Diego. 1414 pp.

Baraff, LS, PJ Clapham, DK Mattila and RS Bowman. 1991. Feeding behavior of a humpback whale in low-latitude waters. *Marine Mammal Science* 7(2): 197-202.

Barlow, J. 2006. Cetacean abundance in Hawaiian waters estimated from a summer/fall survey in 2002. *Marine Mammal Science* 22(2): 446-464.

Baumgartner, MF. 1997. The distribution of Risso's dolphin (*Grampus griseus*) with respect to the physiography of the northern Gulf of Mexico. *Marine Mammal Science* 13(3): 614-638.

Bearzi, G, RR Reeves, G Notarbartolo Di Sciara, E Politi, A Canadas, A Frantzis and B Mussi. 2003. Ecology, status and conservation of short-beaked common dolphins *Delphinus delphis* in the Mediterranean Sea. *Mammal Review* 33(3): 224-252.

Beatson, E. 2007. The diet of pygmy sperm whales, *Kogia breviceps*, stranded in New Zealand: implications for conservation. *Rev Fish Biol Fisheries* 17:295–303.

Beatson, E, S O'Shea and M Ogle. 2007. First report on the stomach contents of long-finned pilot whales, *Globicephala melas*, stranded in New Zealand. *New Zealand Journal of Zoology* 34: 51-56.

Bello, G. 1992b. Stomach contents of a Risso’s dolphin. Do dolphins compete with fishermen and swordfish? *European Research Cetaceans* 6: 199-202.

Benoit-Bird, KJ and WWL Au. 2003. Prey dynamics affect foraging by a pelagic predator (*Stenella longirotris*) over a range of spatial and temporal scales. *Behavioral Ecology and Sociobiology* 53: 364-373.

Best, PB. 1977. Two allopatric forms of Bryde’s whale off South Africa. *Report to the International Whaling Commission* (Spec Iss 1): 10-38.

Blanco C and JA Raga. 2000. Cephalopod prey of two *Ziphius cavirostris* (Cetacea) stranded on the western Mediterranean coast. *Journal of the Marine Biological Association of the United Kingdom* 80 (2): 381-382

Blanco, C, MA Raduan and JA Raga. 2006. Diet of Risso's dolphin (*Grampus griseus*) in the western Mediterranean Sea. *Scientia Marina* 70(3): 407-411.

Blanco, C, J Aznar and JA Raga. 1995. Cephalopods in the diet of the striped dolphin *Stenella coeruleoalba* from the western Mediterranean during an epizootic in 1990. *Journal of Zoology* 237 (1): 151-158.

Blix, AS. and LP Folkow. 1995. Daily energy expenditure in free living minke whales. *Acta Physiologica Scandinavica* 153(1): 61-6.

Clapham, PJ. 2002. Humpback whale. Pp. 589-592 In: WF Perrin, B Wursig and JGM Thewissen (eds) *Encyclopedia of Marine Mammals*. Academic Press: San Diego. 1414 pp.

Clarke, M and R Young. 1998. Description and analysis of cephalopod beaks from stomachs of six species of odontocete cetaceans stranded on Hawaiian shores. *Journal Marine Biological Association UK* 78: 623-641.

Corkeron PJ and AR Martin. 2004. Ranging and diving behaviour of two 'offshore' bottlenose dolphins, *Tursiops* sp., off eastern Australia. *Journal of the Marine Biological Association of the United Kingdom* 84:465-468

Croll DA, A Acevedo-Gutierrez, BR Tershy and J Urban-Ramirez. 2001a. The diving behavior of blue and fin whales: is dive duration shorter than expected based on oxygen stores? *Comparative Biochemistry and Physiology a-Molecular and Integrative Physiology* 129:797-809.

Davis, RW, N Jaquet, D Gendron, U Markaida, G Bazzino and W Gillly. 2007. Diving behavior of sperm whales in relation to behavior of a major prey species, the jumbo squid, in the Gulf of California, Mexico. *Marine Progress Series* 333: 291-302.

DoN. 2005. Marine Resources Assessment for the Marianas Operating Area. Pacific Division, Naval Facilities Engineering Command, Pearl Harbor, Hawaii. Contract # N62470-02-D-9997, CTO 0027. Prepared by Geo-Marine Incorporated, Plano, TX. Available from: www.portal.navfac.navy.mil/portal/page?_pageid=181,3986942&_dad=portal&_schema=PORTAL.

Dietz, R, J Teilmann, MP Heide Jorgensen and MK Jensen. 2002. Satellite tracking of humpback whales in West Greenland. National Environmental Research Institute, Ministry of the Environment, Denmark. NERI Technical Report 411. Available from: http://www2.dmu.dk/1_viden/2_publikationer/3_fagrapporter/rapporter/FR411.pdf.

Dolar, MLL. 2002. Fraser's dolphin. Pp. 485-487 In: WF Perrin, B Wursig and JGM Thewissen (eds) *Encyclopedia of Marine Mammals*. Academic Press: San Diego. 1414 pp.

Dolar, MLL, WA Walker, GL Kooyman and WF Perrin. 2003. Comparative feeding ecology of spinner dolphins (*Stenella longirostris*) and Fraser's dolphins (*Lagenodelphis hosei*) in the Sulu Sea. *Marine Mammal Science* 19(1): 1-19.

Dolphin, WF. 1988. Foraging dive patterns of humpback whales, *Megaptera novaeangliae*, in southeast Alaska: a cost-benefit analysis. *Canadian Journal of Zoology* 66: 2432-2441.

Dolphin, WF. 1987a. Dive behavior and estimated energy expenditures of foraging humpback whales in Southeast Alaska. *Canadian J. Zoology* 65: 354-362.

Donahue, MA and WA Perryman. 2002. Pygmy killer whale. Pp. 1009-1010 In: WF Perrin, B Wursig and JGM Thewissen (eds) *Encyclopedia of Marine Mammals*. Academic Press: San Diego. 1414 pp.

Drouot, V, A Gannier, and JC Goold. 2004. Diving and feeding behaviour of sperm whales (*Physeter macrocephalus*) in the northwestern Mediterranean Sea. *Aquatic Mammals* 30(3): 419-426.

Estes, JA, MT Tinker, TM Williams and DF Doak. 1998. Killer whale predation on sea otters linking oceanic and nearshore ecosystems. *Science* 282: 473-476.

Ferguson, MC and J Barlow. 2003. Addendum: Spatial distribution and density of cetaceans in the eastern tropical Pacific Ocean based on summer/fall research vessel surveys in 1986-96. Southwest Fisheries Science Center Administrative Report LJ-01-04 (Addendum). Available from http://swfsc.noaa.gov.

Ford, JKB. 2002. Killer whale. Pp. 669-676 In: WF Perrin, B Wursig and JGM Thewissen (eds) *Encyclopedia of Marine Mammals*. Academic Press: San Diego. 1414 pp.

Ford, JKB, GM Ellis, LG Barrett-Lennard, AB Morton, RS Palm and KC Balcomb III. 1998. Dietary specialization in two sympatric populations of killer whale (*Orcinus orca*) in coastal British Columbia and adjacent waters. *Canadian Journal of Zoology* 76: 1456-1471.

Gales, R, D Pemberton, M Clarke and CC Lu. 1992. Stomach contents of long-finned pilot whales (*Globicephala melaena*) and bottlenose dolphins (*Tursiops truncatus*) in Tasmania. *Marine Mammal Science* 8 (4): 405–413.

Gannon, DP, AJ Read, JE Craddock and JG Mead. 1997. Stomach contents of long-finned pilot whales (*Globicephala melaena*) stranded on the US mid-Atlantic coast. *Marine Mammal Science* 13(3): 405-418.

Gilmartin, WG and J Forcada. 2002. Monk seals. Pp. 756-759 In: WF Perrin, B Wursig and JGM Thewissen (eds) *Encyclopedia of Marine Mammals*. Academic Press: San Diego. 1414 pp.

Goldbogen, JA, J Calambokidis, RE Shadwick, EM Oleson, MA McDonald and JA Hildebrand. 2006. Kinematics of foraging dives and lunge-feeding in fin whales. *Journal of Experimental Biology* 209(7):1231-1244.

Hain, JHW, SL Ellis, RD Kenney, PJ Clapham, BK Gray, MT Weinrich and IG Babb. 1995. Apparent bottom feeding by humpback whales on Stellwagen Bank. *Marine Mammal Science* 11(4): 464-479.

Hamilton, PK, GS Stone and SM Martin. 1997. Note on a deep humpback whale *Megaptera novaeangliae* dive near Bermuda. *Bulletin of Marine Science* 61(2): 491-494.

Haug, T, U Lindstrom and KT Nilssen. 2002. Variations in minke whale diet and body condition in response to ecosystem changes in the Barents Sea. *Sarsia* 87: 409-422.

Haug, T, U Lindstrom, KT Nilssen, I Rottingen and HJ Skaug. 1996. Diet and food availability for northeast Atlantic minke whales. *Report of the International Whaling Commission* 46: 371-382.

Haug, T, H Gjosaeter, U Lindstrom and KT Nilssen. 1995. Diet and food availability for northeast Atlantic minke whales during summer 1992. *ICES Journal of Marine Science* 52: 77-86.

Heide-Jorgensen MP, D Bloch, E Stefansson, B Mikkelsen, LH Ofstad and R Dietz. 2002. Diving behaviour of long-finned pilot whales *Globicephala melas* around the Faroe Islands. *Wildlife Biology* 8:307-313.

Helweg, DA and LM Herman. 1994. Diurnal patterns of behaviour and group membership of humpback whales (*Megaptera novaeangliae*) wintering in Hawaiian waters. *Ethology* 98: 298-311.

Heyning, JE. 2002. Cuvier’s beaked whale. Pp 305-307 In: WF Perrin, B Wursig and JGM Thewissen (eds) *Encyclopedia of Marine Mammals*. Academic Press: San Diego. 1414 pp.

Hindell, MA. 2002. Elephant seals. Pp 370-373 In: WF Perrin, B Wursig and JGM Thewissen (eds) *Encyclopedia of Marine Mammals*. Academic Press: San Diego. 1414 pp.

Hoelzel, AR, CW Potter and PB Best. 1998. Genetic differentiation between parapatric 'nearshore' and 'offshore' populations of the bottlenose dolphin. *Proceedings of the Royal Society of London* 265: 1177-1183.

Hoelzel, A, EM Dorsey and J Stern. 1989. The foraging specializations of individual minke whales. *Animal Behavior* 38: 786-794.

Horwood, J. 2002. Sei whale. Pp. 1069-1071 In: WF Perrin, B Wursig and JGM Thewissen (eds) *Encyclopedia of Marine Mammals*. Academic Press: San Diego. 1414 pp.

Jahoda, M, C Almirante, A Azzellino, S Panigada, M Zanardelli and S Canese, S. 1999. 3D-tracking as a tool for studying behavior in Mediterranean fin whales (*Balaenoptera physalus*), p. 89, 13th Biennial Conference on the Biology of Marine Mammals.

Jaquet, N, S Dawson and E Slooten. 2000. Seasonal distribution and diving behavior of male sperm whales off Kaikoura: foraging implications. *Canadian Journal of Zoology* 78(3): 407-419.

Jefferson, TA. 2002b. Rough-toothed dolphin. Pp. 1055-1059 In: WF Perrin, B Wursig and JGM Thewissen (eds) *Encyclopedia of Marine Mammals.* Academic Press: San Diego. 1414 pp.

Jefferson, TA and NB Barros. 1997. *Peponocephala electra*. Mammalian Species 553:1-6.

Jefferson, TA, S Leatherwood and MA Webber. 1993. *Marine mammals of the world. FAO Species Identification Guide.* United Nations Environment Programme, Food and Agriculture Organization of the United Nations. 320 pp.

Johnson, M, PT Madsen, WMX Zimmer, N Aguilar de Soto, and PL Tyack. 2004. Beaked whales echolocate on prey. *Proceedings of the Royal Society, London B* (Suppl.) 271: S383-S386.

Johnston, DW, LH Thorne and AJ Read. 2005. Fin whales and minke whales exploit a tidally driven island wake ecosystem in the Bay of Fundy. *Marine Ecological Progress Series*305: 287-295.

Kato, H. 2002. Bryde’s whales. Pp 171-177 In: WF Perrin, B Wursig and JGM Thewissen (eds) *Encyclopedia of Marine Mammals*. Academic Press: San Diego. 1414 pp.

Kawamura, A. 1980. Food habits of the Bryde’s whales taken in the South Pacific and Indian Oceans. *Scientific Reports of the Whales Research Institute* 32: 1-23.

Klatsky, LJ, RS Wells and JC Sweeney. 2007. Offshore bottlenose dolphins (*Tursiops truncatus*): Movement and dive behavior near the Bermuda Pedestal. *Journal of Mammalogy* 88(1):59-66.

Koen Alonso, M, SN Pedraza, ACM Schiavini, RNP Goodall and EA Crespo. 1999. Stomach contents of false killer whales (*Pseudorca crassidens*) stranded on the coasts of the Strait of Magellan, Tierra del Fuego. *Marine Mammal Science* 15(3): 712-724.

Laerm, J, F Wenzel, JE Craddock, D Weinand, J McGurk, MJ Harris, GA Early, JG Mead, CW Potter and NB Barros. 1997. New prey species for northwester Atlantic humpback whales. *Marine Mammal Science* 13(4): 705-711.

Lagerquist, BA, KM Stafford and BR Mate. 2000. Dive characteristics of satellite-monitored blue whales (*Balaenoptera musculus*) off the central California coast. *Marine Mammal Science* 16(2): 375-391.

Ligon, AD and RW Baird. 2001. Diving behavior of false killer whales off Maui and Lana'I, Hawaii. Abstract presented at 14th Biennial Conference on the Biology of Marine Mammals, Vancouver, Canada, December, 2001. Available from www.cascadiaresearch.org.

Lindstrom, U and T Haug. 2001. Feeding strategy and prey selection in minke whales foraging in the southern Barents Sea during early summer. *J. Cetacean Research and Management* 3: 239-249.

London, JM. 2006. Harbor seals in Hood Canal: Predators and Prey. PhD Dissertation, University of Washington.

Madsen, PT, M Johns, N Aguilar de Soto, WMX Zimmer and P Tyack. 2005. Biosonar performance of foraging beaked whales (*Mesoplodon densirostris*). *The Journal of Experimental Biology* 208: 181-194.

Marsh, H. 2002. Dugong. Pp. 344-347 In: WF Perrin, B Wursig and JGM Thewissen (eds) *Encyclopedia of Marine Mammals*. Academic Press: San Diego. 1414 pp.

McAlpine, DF. 2002. Pygmy and dwarf sperm whales. Pp. 1007-1009 In: WF Perrin, B Wursig and JGM Thewissen (eds) *Encyclopedia of Marine Mammals*. Academic Press: San Diego. 1414 pp.

McAlpine, DF, LD Murison and EP Hoberg. 1997. New records for the pygmy sperm whale, *Kogia breviceps* (Physeteridae) from Atlantic Canada with notes on diet and parasites. *Marine Mammal Science* 13(4): 701-704.

Miyashita, T. 1993. Distribution and abundance of some dolphins taken in the north Pacific driftnet fisheries. *Bulletin of the International North Pacific Fisheries Commission* 53(III): 435-449.

Miyazaki N and WF Perrin. 1994. Rough-toothed dolphin *Steno bredanensis* (Lesson, 1828). Pp 1-22 In: SH Ridgway and SR Harrison (eds.), *Handbook of Marine Mammals* Vol. 5: The first book of dolphins. Academic Pres, London.

Mobley, JR, SS Spitz, RA Grotefendt, PH Forestell, AS Frankel and GB Bauer. 2001b. Abundance of Humpback Whales in Hawaiian Waters: Results of 1993-2000 Aerial Surveys. Report to the Hawaiian Islands Humpback Whale National Marine Sanctuary. Available from: http://hawaiihumpbackwhale.noaa.gov/research/HIHWNMS_Research_Mobley.pdf.

Murase, H, T Tamura, H Kiwada, Y Fujise, H Watanabe, H Ohizumi, S Yonezaki, H Okamura and S Kawahura. 2007. Prey selection of common minke (*Balaenoptera acutorostrata*) and Bryde's (*Balaenoptera edeni*) whales in the western North Pacific in 2000 and 2001. *Fisheries Oceanography* 16(2): 186-201.

Nawojchik, R, DJ St. Aubin and A Johnson. 2003. Movements and dive behavior of two stranded, rehabilitated long-finned pilot whales (*Globecephala melas*) in the Northwest Atlantic. *Marine Mammal Science* 19(1): 232-239.

Nemoto, T and A Kawamura. 1977. Characteristics of food habits and distribution on baleen whales with special reference to the abundance of north Pacific sei and Bryde's whales. *Report to the International Whaling Commission* (Special Issue 1): 80-87.

Notarbartolo-di-Sciara, G, M Zanardelli, M Jahoda, S Panigada and S Airoldi. 2003. The fin whale *Balaenoptera physalus* (L. 1758) in the Mediterranean Sea. *Mammal Review* 33(2): 105-150.

Ohizumi, H, M Yoshioka, K Mori and N Miyazaki. 1998. Stomach contents of common dolphins (*Delphinus delphis*) in the pelagic western North Pacific. *Marine Mammal Science* 14(4): 835-844.

Olson, PA and SB Reilly. 2002. Pilot whales. Pp. 898-903 In: WF Perrin, B Wursig and JGM Thewissen (eds) *Encyclopedia of Marine Mammals*. Academic Press: San Diego. 1414 pp.

Ozturk, B, A Salman, AA Ozturk and A Tonay. 2007. Cephalopod remains in the diet of striped dolphins (*Stenella coeruleoalba*) and Risso's dolphins (*Grampus griseus*) in the eastern Mediterranean Sea. *Vie et Milieu - Life and Environment* 57(1/2): 53-59

Palka, D and M Johnson, eds. 2007. Cooperative research to study dive patterns of sperm whales in the Atlantic Ocean. OCS Study MMS 2007-033. New Orleans, Louisiana: Gulf of Mexico Region, Minerals Management Service. Available from http://www.gomr.mms.gov.

Panigada, S, G Pesante, M Zanardelli and S Oehen. 2003. Day and night-time behaviour of fin whales in the western Ligurian Sea. Oceans 2003, Proceedings 1: 466-471.

Panigada, S, G Notarbartolo di Sciara and MZ Panigada. 2006. Fin whales summering in the Pelagos Sanctuary (Mediterranean Sea): Overview of studies on habitat use and diving behaviour. *Chemistry and Ecology* 22(Supp.1):S255-S263.

Panigada, S, M Zanardelli, S Canese and M Jahoda. 1999. How deep can baleen whales dive? *Marine Ecology Progress Series* 187: 309-311.

Papastavrou V, SC Smith and H Whitehead. 1989. Diving behavior of the sperm whale, *Physeter macrocephalus*, off the Galapagos Islands [Ecuador]. *Canadian Journal of Zoology* 67:839-846.

Pauly, D, AW Trites, E Capuli and V Chrisensen. 1998. Diet composition and trophic levels of marine mammals. *ICES Journal of Marine Science* 55: 467-481.

Perrin, WF. 2002a. Pantropical spotted dolphin. Pp. 865-867 In: WF Perrin, B Wursig and JGM Thewissen (eds) *Encyclopedia of Marine Mammals*. Academic Press: San Diego. 1414 pp.

Perrin. WF. 2002b. Common dolphins. Pp. 245-248 In: WF Perrin, B Wursig and JGM Thewissen (eds) *Encyclopedia of Marine Mammals*. Academic Press: San Diego. 1414 pp.

Perrin, WF. 2002c. Melon-headed whales. Pp. 733-735 In: WF Perrin, B Wursig and JGM Thewissen (eds) *Encyclopedia of Marine Mammals*. Academic Press: San Diego. 1414 pp.

Perrin, WF. 2002d. Spinner dolphin. Pp. 1174-1178 In: WF Perrin, B Wursig and JGM Thewissen (eds) *Encyclopedia of Marine Mammals*. Academic Press: San Diego. 1414 pp.

Perrin, WF and RL Brownell, Jr. 2002. Minke whales. Pp. 750-754 In: WF Perrin, B Wursig and JGM Thewissen (eds) *Encyclopedia of Marine Mammals*. Academic Press: San Diego. 1414 pp.

Pitman, RL. 2002a. Indo-pacific beaked whale. Pp. 615-617 In: WF Perrin, B Wursig and JGM Thewissen (eds) *Encyclopedia of Marine Mammals*. Academic Press: San Diego. 1414 pp.

Pitman, RL. 2002b. Mesoplodont whales. Pp. 738-742 In: WF Perrin, B Wursig and JGM Thewissen (eds) *Encyclopedia of Marine Mammals*. Academic Press: San Diego. 1414 pp.

Pusineri, C, V Magnin, L Meynier, J Spitz, S Hassani and V Ridoux. 2007. Food and feeding ecology of the common dolphin (*Delphinus delphis*) in the oceanic northeast Atlantic and comparison with its diet in neritic areas. *Marine Mammal Science* 23(1): 30-47.

Reeves, RR, BS Stewart, PJ Clapham, and JA Powell. 2002. *National Audubon Society Guide to Marine Mammals of the World*. Alfred A Knopf: New York.

Richard, KR and MA Barbeau. 1994. Observations of spotted dolphins feeding nocturnally on flying fish. *Marine Mammal Science* 10(4): 473-477.

Roberts, SM. 2003. Examination of the stomach contents from a Mediterranean sperm whale found south of Crete, Greece. *Journal of the Marine Biological Association UK* 83: 667-670.

Robertson, KM and SJ Chivers. 1997. Prey occurrence in pantropical spotted dolphins, *Stenella attenuata*, from the eastern tropical Pacific. *Fishery Bulletin* 95(2): 334-348.

Robison, BH and JE Craddock. 1983. Mesopelagic fishes eaten by Fraser's dolphin, *Lagenodelphis hosei*. *Fishery Bulletin* 81(2): 283-289.

Rossbach, K and D Herzing. 1997. Underwater observations of benthic-feeding bottlenose dolphins (*Tursiops truncatus*) near Grand Bahama Island, Bahamas. *Marine Mammal Science* 13(3): 498-504.

Santos, RA and M Haimovici. 2001. Cephalopods in the diet of marine mammals stranded or incidentally caught along southeastern and southern Brazil (21-34S). *Fisheries Research* 52(1-2): 99-112.

Santos, MB, GJ Pierce, J Herman, A Lopez, A Guerra, E Mente and MR Clarke. 2001. Feeding ecology of Cuvier's beaked whale (*Ziphius cavirostris*): a review with new information on the diet of this species. *Journal of the Marine Biological Association of the United Kingdom* 81: 687-694.

Saulitis, E, C Matkin, L Barrett-Lennard, K Heise and G Ellis. 2000. Foraging strategies of sympatric killer whale (*Orcinus orca*) populations in Prince William Sound, Alaska. *Marine Mammal Science* 16(1): 94-109.

Scott MD, AA Hohn, AJ Westgate, JR Nicolas, BR Whitaker and WB Campbell. 2001. A note on the release and tracking of a rehabilitated pygmy sperm whale (*Kogia breviceps*). *Journal of Cetacean Research and Management* 3:87-94.

Sears, R. 2002. Blue whale. Pp. 112-116 In: WF Perrin, B Wursig and JGM Thewissen (eds) *Encyclopedia of Marine Mammals*. Academic Press: San Diego. 1414 pp.

Shane, SH, RS Wells and B Wursig. 1986. Ecology, behavior and social organization of the bottlenose dolphin: a review. *Marine Mammal Science* 2(1): 34-63.

Sinclair, EHS. 1992. Stomach contents of four short-finned pilot whales (*Globicephala melas*) from the southern California Bight. *Marine Mammal Science* 8(1): 76-81.

Smith, SC and H Whitehead. 2000. The diet of Galapagos sperm whales *Physeter macrocephalus* as indicated by fecal sample analysis. *Marine Mammal Science* 16(2): 315-325.

Soto, NA, M Johnson, PT Madsen, PL Tyack, A Bocconcelli and JF Borsani. 2006. Does intense ship noise disrupt foraging in deep-diving Cuvier's beaked whales (*Ziphius cavirostris*)? *Marine Mammal Science* 22(3): 690-699.

SRS-Parsons, Geo-Marine, Inc. and Bio-Waves, Inc. 2007. Marine mammal and sea turtle survey and density estimates for Guam and the Commonwealth of the Northern Mariana Islands. Final Report Contract No. N68711-02-D-8043; Task Order No 0036. Prepared for Naval Facilities Engineering Command Pacific. Provided as GFE from SRS-Parsons.

Tiemann, CO, AM Thode, J Straley, V O'Connell and K Folkert. 2006. Three-dimensional localization of sperm whales using a single hydrophone. *J. Acoustical Society of America* 120(4):2355-2365.

Tyack, PL, M Johnson, N Aguilar Soto, A Sturlese and PT Madsen. 2006. Extreme diving of beaked whales. *Journal of Experimental Biology* 209(21):4238-4253.

Wahlberg M. 2002. The acoustic behaviour of diving sperm whales observed with a hydrophone array. *Journal of Experimental Marine Biology & Ecology* 281:53-62.

Wang, MC, WA Walker, KT Shao and LS Chou. 2003. Feeding habits of the pantropical spotted dolphin, *Stenella attenuata*, off the eastern coast of Taiwan. *Zoological Studies* 42(2): 368-378.

Watkins, WA, MA Daher, NA DiMarzio, A Samuels, D Wartzok, KM Fristrup, PW Howey and RR Maiefski. 2002. Sperm whale dives tracked by radio tag telemetry. *Marine Mammal Science* 18(1): 55-68.

Watkins, WA, MA Daher, K Fristrup and G Notarbartolo di Sciara. 1994. Fishing and acoustic behavior of Fraser's dolphin (*Lagenodelphins hosei*) near Dominica, southeast Caribbean. *Caribbean Journal of Science* 30 (1-2): 76-82.

Watkins, WA, MA Daher, KM Fristrup, TJ Howald and G Notarbartolo di Sciara. 1993. Sperm whales tagged with transponders and tracked underwater by sonar. *Marine Mammal Science* 9: 55-67.

Watwood, SL, PJO Miller, M Johnson, PT Madsen and PL Tyack. 2006. Deep-diving foraging behaviour of sperm whales (*Physeter macrocephalus*). *Journal of Ecology* 75: 814-825.

Wells, RS and MD Scott. 2002. Bottlenose dolphins. Pp 122-128 In: WF Perrin, B Wursig and JGM Thewissen (eds) *Encyclopedia of Marine Mammals*. Academic Press: San Diego. 1414 pp.

Whitehead, H. 2002. Sperm whale. Pp. 1165-1172 In: WF Perrin, B Wursig and JGM Thewissen (eds) *Encyclopedia of Marine Mammals*. Academic Press: San Diego. 1414 pp.

Wurtz, M and D Marrale. 1993. Food of striped dolphin, *Stenella coeruleoalba*, in the Ligurian Sea. *Journal Marine Biological Association UK* 73: 571-578.

Wurtz, M, R Poggi and MR Clarke. 1992. Cephalopods from the stomach of a Risso's dolphin (*Grampus griseus*) from the Mediterranean. *Journal of the Marine Biological Association UK* 72: 861-867.

Appendix G-1. Summary of depth information for marine mammal species with densities in the MIRC.

GENERAL INFORMATION					DEPTH SPECIFIC INFORMATION					
Common Name	**Food Preference**	**Depth or Oceanic Preference**	**References**		**Behavioral State**	**Geographic Region**	**Depth Information**	**Depth Distribution**	**Sample Size/ Time of Year/Method**	**References**
MYSTICETES - Baleen whales										
Blue whale	Euphausiid crustaceans, including *Euphasia* sp and *Thysanoessa* sp	Coastal as well as offshore	Sears (2002); Croll et al. (2001a); Acevado et al. (2002); Bannister (2002)		Feeding at depth	Northeast Pacific (Mexico, California)	Mean depth 140 +- 46 m; mean dive time 7.8 +- 1.9 min		Seven whales/ May-August/Time-depth-recorder	Croll et al. (2001a)
Blue whale					Feeding near surface; surface intervals between deeper dives	Northeast Pacific (central California)	Mean depth 105 +- 13 m; mean dive time 5.8 +- 1.5 min	78% in 0-16 m; 9% in 17-32; 13% in >32 m; most dives to <16 m and 96-152 m ranges, but only 1.2% of total time was spent in deeper range	One whale/ August-September/ Satellite depth-sensor-tag	Lagerquist et al. (2000)
Blue whale					Non-feeding	Northeast Pacific (Mexico, California)	Mean depth 68 +- 51 m; mean dive time 4.9 +- 2.5 min; most dives to ~30 m with occasional deeper V-shaped dives to >100m		Seven whales/ May-August/Time-depth-recorder	Croll et al. (2001a)

Appendix G-1. Summary of depth information for marine mammal species with densities in the MIRC. (cont'd)

GENERAL INFORMATION					DEPTH SPECIFIC INFORMATION					
Fin whale	Planktonic crustaceans, including *Thyanoessa* sp and *Calanus* sp, as well as schooling fishes such as capelin (*Mallotus*), herring (*Clupea*) and mackerel (*Scomber*)	Pelagic with some occurrence over continental shelf areas, including in island wake areas of Bay of Fundy	Aguilar (2002); Croll et al. (2001a); Acevado et al. (2002): Notarbartolo-di-Sciara et al. (2003); Bannister (2002); Johnston et al. (2005)		Feeding at depth	Northeast Pacific (Mexico, California)	Mean depth 98 +- 33 m; mean dive time 6.3+- 1.5 min		Fifteen whales/ April-October/Time-depth-recorder	Croll et al. (2001a)
Fin whale					Non-feeding	Northeast Pacific (Mexico, California)	Mean depth 59 +-30 m; mean dive time 4.2 +- 1.7 min; most dives to ~ 30 m with occasional deeper V-shaped dives to >90 m		Fifteen whales/ April-October/Time-depth-recorder	Croll et al. (2001a)
Fin whale					Feeding	Mediterranean (Ligurian Sea)	shallow dives (mean 26-33 m, with all <100m) until late afternoon; then dives in excess of 400 m (perhaps to 540 m); in one case a whale showed deep diving in midday; deeper dives probably were to feed on specific prey (*Meganyctiphanes norvegica*) that undergo diel vertical migration		Three whales/ Summer/ Velocity-time-depth-recorder	Panigada et al. (1999); Panigada et al. (2003); Panigada et al. (2006)

Appendix G-1. Summary of depth information for marine mammal species with densities in the MIRC. (cont'd)

GENERAL INFORMATION					DEPTH SPECIFIC INFORMATION					
Fin whale					Traveling	Mediterranean (Ligurian Sea)	shallow dives (mean 9.8 +- 5.3 m, with max 20 m) , shorter dive times and slower swimming speed indicate travel mode; deep dives (mean 181.3 +-195.4 m, max 474 m), longer dive times and faster swimming speeds indicate feeding mode		One whale/ Summer/ Velocity-time-depth-recorder	Jahoda et al. (1999)
Fin whale					Feeding	Northeast Pacific (Southern California Bight)	mean dive depth 248+-18 m; total dive duration mean 7.0+-1.0 min with mean descent of 1.7+-0.4 min and mean ascent of 1.4+-0.3 min; 60% (i.e., 7.0 min) of total time spent diving with 40% (i.e., 4.7 min) total time spent near sea surface (<50m)	44% in 0-49m (includes surface time plus descent and ascent to 49 m); 23% in 50-225 m (includes descent and ascent times taken from Table 1 minus time spent descending and ascending through 0-49 m); 33% at >225 m (total dive duration minus surface, descent and ascent times)	Seven whales/ August/ Bioacoustic probe	Goldbogen et al. (2006)
Fin whale					Feeding	Northeast Pacific (Southern California Bight)	Distribution of foraging dives mirrored distribution of krill in water column, with peaks at 75 and 200-250 m.		Two whales/ September-October/ Time-depth-recorder	Croll et al. (2001a)

Appendix G-1. Summary of depth information for marine mammal species with densities in the MIRC. (cont'd)

GENERAL INFORMATION					DEPTH SPECIFIC INFORMATION					
Sei whale	Copepods, amphipods, euphausiids, shoaling fish and squid	More open ocean than coastal	Horwood (2002); Jefferson et al. (1993); Nemoto and Kawamura (1977); Bannister (2002)		Feeding	Northwest Pacific - coastal	skim feeder that takes swarms in low density		Several/ Year-round/ Stomach content analysis	Nemoto and Kawamura (1977)
Bryde's whale	Pelagic schooling fish, small crustaceans (euphausiids, copepods), cephalopods; feeding is regionally different; preferred both anchovy and krill in Northwestern Pacific	Coastal and Offshore; off South Africa inshore form feeds on epipelagic fish (e.g., anchovies) while offshore form feeds on mesopelagic fish and euphausiids	Kato (2002); Murase et al. (2007); Best (1977); Bannister (2002)		Feeding	South Pacific and Indian Oceans	Main prey items were euphausiids, including *Euphausia* sp and *Thysanoessa* sp; most feeding apparently at dawn and dusk		Several hundred/ year-round/ stomach content	Kawamura (1980)
Minke whale	Regionally dependent; can include euphausiids, copepods, small fish: Japanese anchovy preferred in western North Pacific, capelin and krill in the Barents Sea	Coastal, inshore and offshore; known to concentrate in areas of highest prey density, including during flood tides	Perrin and Brownell (2002); Jefferson et al. (1993); Murase et al. (2007); Bannister (2002); Lindstrom and Haug (2001); Johnston et al. (2005); Hoelzel et al. (1989); Haug et al. (2002); Haug et al. (1995); Haug et al. (1996)		Feeding, Searching	North Atlantic (Norway)	Searching for capelin at less than 20 m, then lunge-feeding at depths from 15 to 55 m, then searching again at shallower depths	Based on time series in Figure 2, 47% of time was spent foraging from 21-55 m; 53% of time was spent searching for food from 0-20 m	One whale/ August/ Dive-depth-transmitters	Blix and Folkow (1995)

Appendix G-1. Summary of depth information for marine mammal species with densities in the MIRC. (cont'd)

GENERAL INFORMATION					DEPTH SPECIFIC INFORMATION					
Minke whale					Feeding	North Pacific (San Juan Islands)	80% of feeding occurred over depths of 20-100m; two types of feeding observed both near surface - lunge feeding and bird association		23 whales/ June-September/ behavioral observations	Hoelzel et al. (1989)
Humpback whale	Pelagic schooling euphausiids and small fish including capelin, herring, mackerel, croaker, spot, and weakfish	Coastal, inshore, near islands and reefs, migration through pelagic waters	Clapham (2002); Hain et al. (1995); Laerm et al. (1997); Bannister (2002)		Feeding	North Atlantic (Stellwagen Bank)	Depths <40 m		Several whales/ August/ Visual Observations	Hain et al. (1995)
Humpback whale					Feeding (possible)	Tropical Atlantic (Bermuda)	Dives to 240 m		One whale/ April/ VHF tag	Hamilton et al. (1997)
Humpback whale					Feeding (in breeding area)	Tropical Atlantic (Samana Bay - winter breeding area)	Not provided; lunge feeding with bubblenet		One whale/ January/ Visual observations	Baraff et al. (1991)
Humpback whale					Breeding	North Pacific (Hawaii)	Depths in excess of 170 m recorded; some depths to bottom, others to mid- or surface waters; dive duration was not necessarily related to dive depth; whales resting in morning with peak in aerial displays at noon	40% in 0-10 m, 27% in 11-20 m, 12% in 21-30 m, 4% in 31-40 m, 3% in 41-50 m, 2% in 51-60 m, 2% in 61-70 m, 2% in 71-80 m, 2% in 81-90 m, 2% in 91-100 m, 3% in >100 m (from Table 3	Ten Males/ February-April/ Time-depth-recorder	Baird et al. (2000a); Helweg and Herman (1994)

Appendix G-1. Summary of depth information for marine mammal species with densities in the MIRC. (cont'd)

GENERAL INFORMATION					DEPTH SPECIFIC INFORMATION					
Humpback whale					Feeding	Northeast Atlantic (Greenland)	Dive data was catalogued for time spent in upper 8 m as well as maximum dive depth; diving did not extend to the bottom (~1,000 m) with most time in upper 4 m of depth with few dives in excess of 400 m	37% of time in <4 m, 25% of time in 4-20 m, 7% of time in 21-35m, 4% of time in 36-50 m, 6% of time in 51-100 m, 7% of time in 101-150 m, 8% of time in 151-200 m, 6% of time in 201-300 m, and <1% in >300 m (from Figure 3.10)	Four whales/ June-July/ Satellite transmitters	Dietz et al. (2002)
Humpback whale					Feeding	North Pacific (Southeast Alaska)	Dives were short (<4 min) and shallow (<60 m); deepest dive to 148m; percent of time at surface increased with increased dive depth and with dives exceeding 60 m; dives related to position of prey patches		Several whales/ July-September/ Passive sonar	Dolphin (1987a); Dolphin (1988)
ODONTOCETES - Toothed whales										
Sperm whale	Squids and other cephalopods, demersal and mesopelagic fish; varies according to region	Deep waters, areas of upwelling	Whitehead (2002); Roberts (2003)		Feeding	Mediterranean Sea	Overall dive cycle duration mean = 54.78 min, with 9.14 min (17% of time) at the surface between dives; no measurement of depth of dive		16 whales/ July-August/ visual observations and click recordings	Drouot et al. (2004)
Sperm whale					Feeding	South Pacific (Kaikoura, New Zealand)	83% of time spent underwater; no change in abundance between summer and winter but prey likely changed between seasons		>100 whales/ Year-round/ visual observations	Jacquet et al. (2000)

Appendix G-1. Summary of depth information for marine mammal species with densities in the MIRC. (cont'd)

GENERAL INFORMATION					DEPTH SPECIFIC INFORMATION					
Sperm whale					Feeding	Equatorial Pacific (Galapagos)	Fecal sampling indicated four species of cephalopods predominated diet, but is likely biased against very small and very large cephalopods; samples showed variation over time and place		Several whales/ January-June/ fecal sampling	Smith and Whitehead (2000)
Sperm whale					Feeding	Equatorial Pacific (Galapagos)	Dives were not to ocean floor (2,000-4,000 m) but were to mean 382 m in one year and mean of 314 in another year; no diurnal patterns noted; general pattern was 10 min at surface followed by dive of 40 min; clicks (indicating feeding) started usually after descent to few hundred meters		Several whales/ January-June/ acoustic sampling	Papastavrou et al. (1989)

Appendix G-1. Summary of depth information for marine mammal species with densities in the MIRC. (cont'd)

GENERAL INFORMATION					DEPTH SPECIFIC INFORMATION					
Sperm whale					Feeding	North Pacific (Baja California)	Deep dives (>100m) accounted for 26% of all dives; average depth 418 +- 216 m; most (91%) deep dives were to 100-500 m; deepest dives were 1,250-1,500m; average dive duration was 27 min; average surface time was 8.0; whale dives closely correlated with depth of squid (200-400 m) during day; nighttime squid were shallower but whales still dove to same depths	74% in <100 m; 24% in 100-500 m; 2% in >500m	Five whales/ October-November/ Satellite-linked dive recorder	Davis et al. (2007)
Sperm whale					Resting/ socializing	North Pacific (Baja California)	Most dives (74%) shallow (8-100 m) and short duration; likely resting and/or socializing		Five whales/ October-November/ Satellite-linked dive recorder	Davis et al. (2007)
Sperm whale					Feeding	North Atlantic (Norway)	Maximum dive depths near sea floor and beyond scattering layer		Unknown # male whales/ July/ hydrophone array	Wahlberg (2002)
Sperm whale					Feeding	North Pacific (Southeast Alaska)	Maximum dive depth if 340 m when fishing activity was absent; max dive depth during fishing activity was 105 m		Two whales/ May/ acoustic monitoring	Tiemann et al. (2006)

Appendix G-1. Summary of depth information for marine mammal species with densities in the MIRC. (cont'd)

GENERAL INFORMATION					DEPTH SPECIFIC INFORMATION					
Sperm whale					Feeding	Northwest Atlantic (Georges Bank)	Dives somewhat more U-shaped than observed elsewhere; animals made both shallow and deep dives; average of 27% of time at surface; deepest dive of 1186 m while deepest depths in area were 1,500-3,000 m so foraging was mid-water column; surface interval averaged 7.1 min		Nine Whales/ July 2003/ DTAG	Palka and Johnson (2007)
Sperm whale					Feeding	Northwest Atlantic (Georges Bank)	37% of total time was spent near surface (0-10m); foraging dive statistics provided in Table 1 and used to calculate percentages of time in depth categories, adjusted for total time at surface	48% in <10 m; 3% in 10-100 m; 7% in 101-300 m; 7% in 301-500 m; 4% in 501-636 m; 31% in >636 m	Six females or immatures/ September-October/ DTAG	Watwood et al. (2006)
Sperm whale					Feeding	Mediterranean Sea	20% of total time was spent near surface (0-10m); foraging dive statistics provided in Table 1 and used to calculate percentages of time in depth categories, adjusted for total time at surface	35% in <10 m; 4% in 10-100 m; 9% in 101-300 m; 9% in 301-500 m; 5% in 501-623 m; 38% in >636 m	Eleven females or immatures/ July/ DTAG	Watwood et al. (2006)

Appendix G-1. Summary of depth information for marine mammal species with densities in the MIRC. (cont'd)

GENERAL INFORMATION					DEPTH SPECIFIC INFORMATION					
Sperm whale					Feeding	Gulf of Mexico	28% of total time was spent near surface (0-10m); foraging dive statistics provided in Table 1 and used to calculate percentages of time in depth categories, adjusted for total time at surface	41% in <10 m; 4% in 10-100 m; 8% in 101-300 m; 7% in 301-468 m; 40% >468 m	20 females or immatures/ June-September/ DTAG	Watwood et al. (2006)
Sperm whale					Feeding/ Resting	North Pacific (Japan)	Dives to 400-1200 m; active bursts in velocity at bottom of dive suggesting search-and-pursue strategy for feeding; 14% of total time was spent at surface not feeding or diving at all, with 86% of time spent actively feeding; used numbers from Table 1 to determine percentages of time in each depth category during feeding then adjusted by total time at surface	31% in <10 m (surface time); 8% in 10-200 m; 9% in 201-400 m; 9% in 401-600 m; 9% in 601-800m; 34% in >800 m	One female/ June/ Time-depth-recorder	Amano and Yoshioka (2003)

Appendix G-1 Summary of depth information for marine mammal species with densities in the MIRC. (cont'd)

GENERAL INFORMATION					DEPTH SPECIFIC INFORMATION					
Sperm whale					Feeding/ Resting	North Atlantic (Caribbean)	Whales within 5 km of shore during day but moved offshore at night; calves remained mostly at surface with one or more adults; night time tracking more difficult due to increased biological noise from scattering layer; both whales spent long periods of time (>2hr) at surface during diving periods		Two whales/ October/ Acoustic transponder	Watkins et al. (1993)
Sperm whale						North Atlantic (Caribbean)	Dives did not approach bottom of ocean (usually >200 m shallower than bottom depth); day dives deeper than night dives but not significantly; 63% of total time in deep dives with 37% of time near surface or shallow dives (within 100 m of surface)		One whale/ April/ Time-depth tag	Watkins et al. (2002)
Sperm whale					Feeding	Northern Pacific (Hawaii)	Cephalopods of several genera recovered		Two animals/ unknown/ stomach contents	Clarke and Young (1998)
Pygmy sperm whale	mid and deep water cephalopods, fish, crustaceans; probably feeding at or near bottom, possibly using suction feeding	continental slope and deep zones of shelf, epi- and meso-pelagic zones	McAlpine (2002); McAlpine et al. (1997)		Feeding	Northwest Atlantic (Canada)	Prey items included squid beaks, fish otolith and crustacean; squids representative of mesopelagic slope-water community		One whale/ December/ Stomach contents	McAlpine et al. (1997)

Appendix G-1. Summary of depth information for marine mammal species with densities in the MIRC. (cont'd)

GENERAL INFORMATION					DEPTH SPECIFIC INFORMATION					
Pygmy sperm whale					Feeding	Southwest Atlantic (Brazil)	Small to medium-sized cephalopods from offshore regions; cephalopods and fish found in animals from shelf regions		unknown animals/ unknown/ stomach contents	Santos and Haimovici (2001)
Pygmy sperm whale					Feeding	South Pacific (New Zealand)	Primarily cephalopod prey of genus *Histioteuthis* sp, mostly immatures, which is know to undergo vertical migrations; also mysids that are usually found at 650 m during day and between 274 and 650 m at night; some prey species also found in shallower (<100 m) depths in trawls		27 whales/ Year round/ Stomach contents	Beatson (2007)
Dwarf sperm whale	Likely feeds in shallower water than *K breviceps*; otherwise food is similar	continental slope and deep zones of shelf, epi- and meso-pelagic zones	McAlpine (2002)							

Appendix G-1. Summary of depth information for marine mammal species with densities in the MIRC. (cont'd)

	GENERAL INFORMATION				DEPTH SPECIFIC INFORMATION					
Cuvier's beaked whale	Meso-pelagic or deep water benthic organisms, particularly squid (Cephalapoda: Teuthoidea); may have larger range of prey species than other deep divers; likely suction feeders based on lack of teeth and enlarged hyoid bone and tongue muscles	Offshore, deep waters of continental slope (200-2,000 m) or deeper	Heyning (2002); Santos et al. (2001); Blanco and Raga (2000)		Feeding	Northeast Pacific (Hawaii)	max dive depth = 1450 m; identified at least three dive categories including inter-ventilation (<4 m, parabolic shape), long duration (>1,000m, U-shaped but with inflections in bottom depth), and intermediate duration (292-568 m, U-shaped); dive cycle usually included one long duration per 2 hours; one dive interval at surface of >65 min; mean depth at tagging was 2131 m so feeding occurred at mid-depths; no difference between day and night diving		Two whales/September -November/Time-depth recorders	Baird et al. (2006a); Baird et al. (2005a)
Cuvier's beaked whale					Feeding	Mediterranean (Ligurian Sea)	Two types of dive, U-shaped deep foraging dives (>500 m, mean 1070 m) and shallower non-foraging dives (<500 m, mean 221 m); depth distribution taken from information in Table 2	27% in <2 m (surface); 29% in 2-220 m; 4% in 221-400 m; 4% in 401-600 m; 4% in 601-800 m; 5% in 801-1070; 27% in >1070 m	Seven whales/ June/ DTAGs	Tyack et al. (2006)

Appendix G-1. Summary of depth information for marine mammal species with densities in the MIRC. (cont'd)

GENERAL INFORMATION					DEPTH SPECIFIC INFORMATION					
Cuvier's beaked whale					Feeding	Mediterranean (Ligurian Sea)	Deep dives broken into three phases: silent descent, vocal-foraging and silent ascent; vocalizations not detected <200m depth; detected when whales were as deep as 1267 m; vocalizations ceased when whale started ascending from dive; clicks ultrasonic with no significant energy below 20 kHz		Two whales/ September/ DTAGs	Johnson et al. (2004); Soto et al. (2006)
Blainville's beaked whale	Feed primarily on mesopelagic squid (Histioteuthis, Gonatus) and some mesopelagic fish; most prey probably caught at >200 m; likely suction feeders based on lack of teeth and enlarged hyoid bone and tongue muscles		Pitman (2002b)		Feeding	Northeast Pacific (Hawaii)	max dive depth = 1408 m; identified at least three dive categories including inter-ventilation (<5 m), long duration (>800m, U-shaped but with inflections in bottom depth), and intermediate duration (6-300 m, U-shaped); dive cycle usually included one long duration,~8 intermediate duration and several shallow interventilation dives; one surface interval of >154 min; no difference between day and night diving		Four whales/ September-November/ Time-depth recorders	Baird et al. (2006a); Baird et al. (2005a)

Appendix G-1. Summary of depth information for marine mammal species with densities in the MIRC. (cont'd)

GENERAL INFORMATION					**DEPTH SPECIFIC INFORMATION**					
Blainville's beaked whale					Feeding	Northeast Pacific (Hawaii)	Mean max dive depth = 1365 m; whales appeared to coordinate dives to ~600 m after which coordination of depths was not prevalent; dives >800 m (>65 min) occurred once/2.5 hour; likely feeding in mid-depth, not bottom feeding;		Three whales/ March-April/ Time-depth recorders	Baird et al. (2006a)
Blainville's beaked whale					Feeding	Northeast Atlantic (Canary Islands)	Two types of dive, U-shaped deep foraging dives (>500 m, mean 835m) and shallower non-foraging dives (<500 m, mean 71 m); depth distribution taken from information in Table 2	26% in <2 m (surface); 41% in 2-71 m; 2% in 72-200 m; 4% in 201-400 m; 4% in 401-600 m; 4% in 601-835; 19% in >835 m	Three whales/ June/ DTAGs	Tyack et al. (2006)
Blainville's beaked whale					Feeding	Northeast Atlantic (Canary Islands)	Deep dives broken into three phases: silent descent, vocal-foraging (including search, approach and terminal phases) and silent ascent; vocalizations not detected <200m depth; detected when whales were as deep as 1267 m; vocalizations ceased when whale started ascending from dive; clicks ultrasonic with no significant energy below 20 kHz		Two whales/ September/ DTAGs	Johnson et al. (2004); Madsen et al. (2005)

Appendix G-1. Summary of depth information for marine mammal species with densities in the MIRC. (cont'd)

GENERAL INFORMATION					DEPTH SPECIFIC INFORMATION					
Ginkgo-toothed beaked whale	Likely meso-pelagic or deep water benthic organisms; likely suction feeders based on lack of teeth and enlarged hyoid bone and tongue muscles	Offshore, deep waters of continental slope (200-2,000 m) or deeper			Pitman (2002b)					
Longman's beaked whale	Likely meso-pelagic or deep water benthic organisms; likely suction feeders based on lack of teeth and enlarged hyoid bone and tongue muscles	Offshore, deep waters of continental slope (200-2,000 m) or deeper	Pitman (2002a); Pitman (2002b)							
Killer whale	Diet includes fish (salmon, herring, cod, tuna) and cephalopods, as well as other marine mammals (pinnipeds, dolphins, mustelids, whales) and sea birds; most populations show marked dietary specialization	Widely distributed but more commonly seen in coastal temperate waters of high productivity	Ford (2002); Estes et al. (1998); Ford et al. (1998); Saulitis et al. (2000); Baird et al. (2006b)		Feeding	North Pacific (Puget Sound)	Resident-type (fish-eater) whales; maximum dive depth recorded 264 m with maximum depth in study area of 330 m; population appeared to use primarily near-surface waters most likely because prey was available there; some difference between day and night patterns and between males and females; depth distribution info from Table 5 in Baird et al. (2003a)	96% at 0-30 m; 4% at >30 m	Eight whales/ Summer-fall/ Time-depth recorders	Baird et al. (2005b); Baird et al. (2003a)
Killer whale					Feeding	Southwest Atlantic (Brazil)	Small to medium-sized cephalopods, both offshore and coastal		unknown animals/ unknown/ stomach contents	Santos and Haimovici (2001)

Appendix G-1. Summary of depth information for marine mammal species with densities in the MIRC. (cont'd)

GENERAL INFORMATION					DEPTH SPECIFIC INFORMATION					
False killer whale	Oceanic squid and fish, but also smaller marine mammals	Mainly pelagic but close to shore near oceanic islands	Baird (2002a); Koen Alonso et al. (1999); Santos and Haimovici (2001)			North Pacific (Hawaii)	Most dives relatively shallow (<53 m) and dive duration was not a predictor of dive depth		Three whales/ Time-depth recorders	Ligon and Baird (2001)
False killer whale					Feeding	Southwest Atlantic (Brazil)	Medium-sized cephalopods in slope regions		three animals/ unknown/ stomach contents	Santos and Haimovici (2001)
Pygmy killer whale	Cephalopods and small fish, but also likely small delphinids	Mainly pelagic but close to shore near oceanic islands	Donahue and Perryman (2002)		Feeding	Southwest Atlantic (Brazil)	Found in slope-oceanic areas; fed on cephalopods and fish		1 animal/ unknown/ stomach contents	Santos and Haimovici (2001)
Short-finned pilot whale	Fish and squid, including cod, turbot, herring, hake and dogfish	continental shelf breaks, slope waters and areas of high topographic relief; some evidence for deeper dives at night	Sinclair (1992); Olson and Reilly (2002); Baird et al. (2003b)		Feeding	North Pacific (Hawaii)	Deepest dives (600-800 m) during the day but rate of deep (>100 m) diving was higher at night when dives were regularly to 300-500 m; long bouts of surface resting and shallow (<100 m) diving occurred only during the day		10 animals/ unk/ time-depth recorders	Baird et al. (2003b)
Short-finned pilot whale						North Pacific (Southern California)	Prey were entirely cephalopods, particularly *Loligo opalescens*, which spawns at depths of 25-35 m		Four animals/ Oct-Dec/ stomach contents	Sinclair(1992)

Appendix G-1. Summary of depth information for marine mammal species with densities in the MIRC. (cont'd)

GENERAL INFORMATION					DEPTH SPECIFIC INFORMATION					
Long-finned pilot whale	Fish and squid, including cod, turbot, herring, hake and dogfish	continental shelf breaks, slope waters and areas of high topographic relief; distribution somewhat farther north but overlapping with *G. macrorhychus*	Baird et al. (2002b)		Feeding	North Atlantic (Faroe Islands)	Most dives <36 m with 90% to 12-17m; 60% of time at less than 7 m; max depth 828 m	60% at <7 m; 36% at 7-17m; 4% at 18-828 m	Three animals/ July/ time-depth recorders	Heide-Jorgenson et al. (2002)
Long-finned pilot whale					Feeding	Southern Ocean (Tasmania)	Prey items included species commonly found from 0-85 m plus several genera found from 400-700 m		Two animals/ July/ stomach contents	Gales et al. (1992)
Long-finned pilot whale					Feeding	Northwest Atlantic (US mid-Atlantic region)	Prey items included long-finned squid and numerous other cephalopods; very few fish remains		Eight animals/ March, April, September/ stomach contents	Gannon et al. (1997)
Long-finned pilot whale					Feeding	South Pacific (New Zealand)	Squid of genus *Nototodarus*, which tend to be found from 0-500 m, as well as a few other species that indicate feeding both near the surface and at the seabed ~150 m		Five animals/ December/ stomach contents	Beatson et al. (2007)

Appendix G-1. Summary of depth information for marine mammal species with densities in the MIRC. (cont'd)

GENERAL INFORMATION					DEPTH SPECIFIC INFORMATION					
Long-finned pilot whale					Feeding	Mediterranean (Ligurian Sea)	Daytime activities all within <16 m of surface; night dives just after sunset were deep (360 and 648 m) perhaps to take advantage of vertically migrating prey		Five animals/ August/ time-depth recorders	Baird et al. (2002b)
Long-finned pilot whale					Feeding	Southwest Atlantic (Brazil)	Fed on offshore cephalopods		unknown animals/ unknown/ stomach contents	Santos and Haimovici (2001)
Melon-headed whale	Squid and fish, occasionally crustaceans in the water column; prey known to occur at depths to 1,500 m; may feed on similar prey types as Fraser's dolphins	Offshore, deeper waters; occasionally near shore in deep water areas	Perrin (2002c); Jefferson and Barros (1997)							
Melon-headed whale					Feeding	Northern Pacific (Hawaii)	Cephalopods of several genera recovered		One animal/ unknown/ stomach contents	Clarke and Young (1998)
Risso's dolphin	Primarily squid eaters and presumably eat mainly at night; known to feed on oceanic species that are also bioluminescent	Water depths from 400-1,000 m but also on continental shelf; utilize steep sections of continental slope in GOM (350-975 m)	Baird (2002b); Baumgartner (1997); Bello (1992b)		Feeding	Mediterranean (western)	Prey items were mainly squids and octopus, and indicated that most feeding occurs on the middle slope from 600-800 m		15 animals/ year round/ stomach contents	Blanco et al. (2006)

Appendix G-1. Summary of depth information for marine mammal species with densities in the MIRC. (cont'd)

GENERAL INFORMATION					DEPTH SPECIFIC INFORMATION					
Risso's dolphin					Feeding	Mediterranean (Turkey)	Prey species (pelagic cephalopods) show greater degree of vertical distribution compared to those utilized by *S. coeruleoalba*; may indicate they dive deeper or are more likely to feed at night		Two animals/ May-June/ stomach contents	Ozturk et al. (2007)
Risso's dolphin					Feeding	Mediterranean (Ligurian Sea)	Diet composed of cephalopods found at daytime depths in excess of 300 m and which may undertake vertical migrations at night		One animal/ August/ stomach contents	Wurtz et al. (1992)
Risso's dolphin					Feeding	Northern Pacific (Hawaii)	Cephalopods of several genera recovered		One animal/ unknown/ stomach contents	Clarke and Young (1998)
Bottlenose dolphin	Large variety of fish and squid, variable between regions; surface, pelagic and bottom fish have all been taken	Coastal, but can also be found on the continental slope, shelf and shelf break	Wells and Scott (2002); Shane et al. (1986)		Feeding	Southwest Atlantic (Brazil)	Small and medium-sized cephalopods found in animals from shelf regions		unknown animals/ unknown/ stomach contents	Santos and Haimovici (2001)
Bottlenose dolphin					Feeding	Southern Ocean (Tasmania)	Prey items included oceanic species that commonly come onto the continental shelf; fairly large-bodied species compared to other regions		Three animals/ July-October/ stomach contents	Gales et al. (1992)
Bottlenose dolphin					Feeding	Tropical Atlantic (Bahamas)	Fed at depths of 7-13 m along the sandy bottom; prey included benthic fishes and eels		May-September/ behavioral observations	Rossbach and Herzing (1997)

Appendix G-1 Summary of depth information for marine mammal species with densities in the MIRC. (cont'd)

GENERAL INFORMATION					DEPTH SPECIFIC INFORMATION					
Bottlenose dolphin					Feeding	Tropical Atlantic (Bahamas)	Daytime dives tended to be shallow (96% within 50 m of surface); diel dive cycle; deeper and more frequent night time dives correlated with nightly vertical migration of mesopelagic prey; depth distribution taken from info in Figure 3; data on time spent at the surface were not published, therefore it was included in the least shallow depth category published	Daytime: 96% at <50 m, 4% at >50 m; Nighttime: 51% at <50 m, 8% at 50-100 m, 19% at 101-250 m, 13% at 251-450 m and 9% at >450 m	3 animals/ June 2003/ satellite-linked time-depth recorders	Klatsky et al. (2007)
Bottlenose dolphin					Feeding	South Pacific (Australia)	66% percent of time in top 5 m of water surface; maximum dive depth >150 m; no apparent diurnal pattern; no relationship between duration and maximum depth of dives		2 animals/ April-November/ satellite-linked time-depth recorders	Corkeron and Martin (2004)
Rough-toothed dolphin	fish and cephalopods, both coastal and oceanic		Jefferson (2002b); Miyazaki and Perrin (1994)				Max recorded dive to 70 m		Unk	Jefferson (2002b)
Rough-toothed dolphin					Feeding	Southwest Atlantic (Brazil)	Small and medium-sized cephalopods found in animals from shelf regions		unknown animals/ unknown/ stomach contents	Santos and Haimovici (2001)

Appendix G-1. Summary of depth information for marine mammal species with densities in the MIRC. (cont'd)

GENERAL INFORMATION					DEPTH SPECIFIC INFORMATION					
Pantropical spotted dolphin	Small epipelagic fishes, squids and crustaceans for offshore forms; near shore forms may feed on benthic fishes; perhaps some nocturnal feeding; probably opportunistic	Near shore and offshore, with possible shifts closer to shore in fall and winter; in eastern tropical Pacific often found in association with tuna; diet suggest feeding at night on vertically migrating prey	Perrin (2002a); Richard and Barbeau (1994); Robertson and Chivers (1987)		Feeding	Southwest Pacific (Taiwan)	Feed primarily on mesopelagic prey, particularly myctophid lanternfish and cephalopods, with some seasonal differences; night distribution of prey appears to be 0-200 m while daytime distribution of prey is >300 m		45 animals/ year round/ stomach contents	Wang et al. (2003)
Pantropical spotted dolphin					Feeding	North Pacific (Hawaii)	Dives deeper at night (mean = 57 m, max = 213 m) than during day (mean = 13 m, max = 122 m) indicating night diving takes advantage of vertically migrating prey; during daytime, 89% of time was within 0-10 m; depth distribution taken from info in figure 4	For activities conducted during daytime-only, the depth distribution would be 89% at 0-10 m, 10% at 11-50 m, 1% at 51-122 m; for activities conducted over a 24-hour period, the depth distribution needs to be modified to reflect less time at surface and deeper depth dives; 80% at 0-10 m, 8% at 11-20 m, 2% at 21-30 m, 2% at 31-40 m, 2% at 41-50 m, and 6% at 51-213 m.	Six animals/ year round/ time-depth recorders	Baird et al. (2001a)
Pantropical spotted dolphin					Feeding	Northern Pacific (Hawaii)	Remains of cephalopods and fish recovered		One animal/ unknown/ stomach contents	Clarke and Young (1998)

Appendix G-1. Summary of depth information for marine mammal species with densities in the MIRC. (cont'd)

GENERAL INFORMATION					DEPTH SPECIFIC INFORMATION					
Striped dolphin	Feed on pelagic fish and squid; squid make up 50-100% of stomach contents in Mediterranean samples	Continental slope, convergence zones and areas of upwelling; ranges of known prey and presence of luminescent organs in prey indicate feeding at night, possibly 200-700 m	Archer (2002); Archer and Perrin (1999)		Feeding	Mediterranean (Turkey)	Prey species (pelagic cephalopods) show lesser degree of vertical distribution compared to those utilized by *G. griseus*		Three animals/ May-June/ stomach contents	Ozturk et al. (2007)
Striped dolphin					Feeding	Mediterranean (western)	Mixed diet of muscular and gelatinous body squids, mainly consisting of oceanic and pelagic or bathypelagic species		28 animals/ unknown/ stomach contents	Blanco et al. (1995)
Striped dolphin					Feeding	North Pacific (Japan)	Myctophid fish accounted for 63% of prey		unknown animals/ unknown/ stomach contents	Archer and Perrin (1999)
Striped dolphin					Feeding	Mediterranean (Ligurian Sea)	Diet composed of cephalopods, crustaceans and bony fishes; cephalopods and bony fishes apparently equal in importance; likely feeding in offshore waters and possibly in the upper water column; opportunistic feeders		23 animals/ unknown/ stomach contents	Wurtz and Marrale (1993)

Appendix G-1. Summary of depth information for marine mammal species with densities in the MIRC. (cont'd)

GENERAL INFORMATION					DEPTH SPECIFIC INFORMATION					
Spinner dolphin	Small mesopelagic fishes, although subpopulations consume benthic fishes	Pantropical; often high-seas, but coastal populations are also known; dives to 600 m or deeper	Perrin (2002d); Benoit-Bird and Au (2003)		Feeding	Southwest Pacific (Sulu Sea, Philippines)	Mainly feed on mesopelagic crustaceans, cephalopods and fish that undertake vertical migrations to about 200 m at night, with less reliance on non-migrating species found to about 400 m; take smaller prey than Fraser's feeding in same area		45 animals/ unknown/ stomach contents	Dolar et al. (2003)
Spinner dolphin					Feeding	North Pacific (Hawaii)	Extremely close association with small, mesopelagic fishes; mean depth always within 10 m of the depth of the highest prey density; feeding at night occurs between 0-400 m as that is the nighttime prey distribution (prey distribution during the day is estimated at 400-700 m); did not spend entire night offshore but often within 1 km of shore if prey density was highest there	100% at 0-50 m; nighttime: 100% at 0-400 m.	Several animals/ June and November/ active acoustic surveys	Benoit-Bird and Au (2003)

Appendix G-1. Summary of depth information for marine mammal species with densities in the MIRC. (cont'd)

GENERAL INFORMATION					DEPTH SPECIFIC INFORMATION					
Fraser's dolphin	mesopelagic fish, crustaceans and cephalopods; take advantage of vertically migrating prey at night	tropical and oceanic except in places where deep water is close to islands; likely feed to at least 500 m and possibly at night	Dolar (2002); Dolar et al. (2003); Jefferson and Leatherwood (1994)		Feeding	Caribbean (Dominica)	herding and feeding of fish school at surface during daylight hours; depth at location varied from 150-200 m to 2,000-2,500 m; short dives as animals sometimes approached the herded fish from below		60-80 animals/ October/ behavioral observations	Watkins et al. (1994)
Fraser's dolphin					Feeding	Southwest Pacific (Sulu Sea, Philippines)	Mesopelagic crustaceans, cephalopods and fish; take larger prey than spinners feeding in same area; likely forage to 600 m but also taking advantage of vertical migrants to 200 m		37 animals/ unknown/ stomach contents	Dolar et al. (2003)
Fraser's dolphin					Feeding	Southwest Atlantic (Brazil)	Cephalopods and fish found in animals from shelf-slope regions		4 animals/ unknown/ stomach contents	Santos and Haimovici (2001)
Fraser's dolphin					Feeding	North Pacific (eastern tropical Pacific)	Mixed diet of mesopelagic fishes (most important component), shrimps and squids; likely feeding at depths from 250-500 m		Three animals/ May/ stomach contents	Robison and Craddock (1982)
Short-beaked common dolphin	Small mesopelagic fishes and squids in the deep scattering layer; epipelagic schooling fishes and market squids	Wide range of habitats, including upwelling areas, oceanic and near shore regions	Perrin (2002b)		Feeding	Southwest Atlantic (Brazil)	Cephalopods and fish found in animals from shelf regions		2 animals/ unknown/ stomach contents	Santos and Haimovici (2001)

Appendix G-1. Summary of depth information for marine mammal species with densities in the MIRC. (cont'd)

GENERAL INFORMATION					DEPTH SPECIFIC INFORMATION					
Short-beaked common dolphin					Feeding	Northeast Atlantic (Bay of Biscay)	Oceanic diet dominated by myctophid fishes (90%), with less reliance on cephalopods; appear to forage preferentially on small schooling, vertically migrating mesopelagic fauna at dusk and early evening		63 animals/ June-August/ stomach contents	Pusineri et al. (2007)
Short-beaked common dolphin					Feeding	Unknown	Dives to 200 m, apparently from study reported by Evans (1994)		Unknown/ unknown/ unknown	Perrin (2002b)
Short-beaked common dolphin					Feeding	Western North Pacific	Primarily myctophid fishes and other warm water fish species; most prey species found are those that migrate vertically to shallower depth at night (within few hundred m) or inhabit upper layer of ocean		Ten animals/ September/ stomach contents	Ohizumi et al. (1998)
Short-beaked common dolphin					Feeding	Mediterranean Sea	Diet of shoaling fish and eurybathic cephalopods and crustaceans			Bearzi et al. (2003)

APPENDIX H

CETACEAN STRANDING REPORT

Description of marine mammal strandings and causes

This Page Intentionally Left Blank

TABLE OF CONTENTS

This Page Intentionally Left Blank

CETACEAN STRANDING REPORT

H.1 WHAT IS A STRANDED MARINE MAMMAL?

When a live or dead marine mammal swims or floats onto shore and becomes "beached" or incapable of returning to sea, the event is termed a "stranding" (Geraci et al., 1999; Perrin and Geraci, 2002; Geraci and Lounsbury, 2005; NMFS, 2007). The legal definition for a stranding within the United States is that " (A) a marine mammal is dead and is (i) on a beach or shore of the United States; or (ii) in waters under the jurisdiction of the United States (including any navigable waters); or (B) a marine mammal is alive and is (i) on a beach or shore of the United States and is unable to return to the water; (ii) on a beach or shore of the United States and, although able to return to the water, is in need of apparent medical attention; or (iii) in the waters under the jurisdiction of the United States (including any navigable waters), but is unable to return to its natural habitat under its own power or without assistance." (16 United States Code [U.S.C.] 1421h).

The majority of animals that strand are dead or moribund (NMFS, 2007). For those that are alive, human intervention through medical aid and/or guidance seaward may be required for the animal to return to the sea. If unable to return to sea, rehabilitation at an appropriate facility may be determined as the best opportunity for animal survival.

Three general categories can be used to describe strandings: single, mass, and unusual mortality events. The most frequent type of stranding is a single stranding, which involves only one animal (or a mother/calf pair) (NMFS, 2007).

Mass stranding involves two or more marine mammals of the same species other than a mother/calf pair (Wilkinson, 1991), and may span one or more days and range over several miles (Simmonds and Lopez-Jurado, 1991; Frantzis, 1998; Walsh et al., 2001; Freitas, 2004). In North America, only a few species typically strand in large groups of 15 or more and include sperm whales, pilot whales, false killer whales, Atlantic white-sided dolphins, white-beaked dolphins, and rough-toothed dolphins (Odell ,1987, Walsh et al., 2001). Some species, such as pilot whales, false-killer whales, and melon-headed whales occasionally strand in groups of 50 to 150 or more (Geraci et al., 1999). All of these normally pelagic off-shore species are highly sociable and usually infrequently encountered in coastal waters. Species that commonly strand in smaller numbers include pygmy killer whales, common dolphins, bottlenose dolphins, Pacific white-sided dolphin Frasier's dolphins, gray whale and humpback whale (West Coast only), harbor porpoise, Cuvier's beaked whales, California sea lions, and harbor seals (Mazzuca et al., 1999, Norman et al., 2004, Geraci and Lounsbury, 2005).

Unusual mortality events (UMEs) can be a series of single strandings or mass strandings, or unexpected mortalities (i.e., die-offs) that occur under unusual circumstances (Dierauf and Gulland, 2001; Harwood, 2002; Gulland, 2006; NMFS, 2007). These events may be interrelated: for instance, at-sea die-offs lead to increased stranding frequency over a short period of time, generally within one to two months. As published by the NMFS, revised criteria for defining a UME include (Hohn et al., 2006b):

(1) A marked increase in the magnitude or a marked change in the nature of morbidity, mortality, or strandings when compared with prior records.

(2) A temporal change in morbidity, mortality, or strandings is occurring.

(3) A spatial change in morbidity, mortality, or strandings is occurring.

(4) The species, age, or sex composition of the affected animals is different than that of animals that are normally affected.

(5) Affected animals exhibit similar or unusual pathologic findings, behavior patterns, clinical signs, or general physical condition (e.g., blubber thickness).

(6) Potentially significant morbidity, mortality, or stranding is observed in species, stocks or populations that are particularly vulnerable (e.g., listed as depleted, threatened or endangered or declining). For example, stranding of three or four right whales may be cause for great concern whereas stranding of a similar number of fin whales may not.

(7) Morbidity is observed concurrent with or as part of an unexplained continual decline of a marine mammal population, stock, or species.

Unusual environmental conditions are probably responsible for most UMEs and marine mammal die-offs (Vidal and Gallo-Reynoso, 1996; Geraci et al., 1999; Walsh et al., 2001; Gulland and Hall, 2005). Table H-1 provides an overview of documented UMEs attributable to natural causes over the past four decades worldwide.

Table H-1. Marine mammal unusual mortality events attributed to or suspected from natural causes 1978-2005.

Year	Species and number	Location	Cause
1978	Hawaiian monk seals (50)	NW Hawaiian Islands	Ciguatoxin and maitotoxin
1979-80	Harbor seals (400)	Massachusetts	Influenza A
1982	Harbor seals	Massachusetts	Influenza A
1983	Multiple pinniped species	West coast of US, Galapagos	El Nino
1984	California sea lions (226)	California	Leptospirosis
1987	Sea otters (34)	Alaska	Saxitoxin
1987	Humpback whales (14)	Massachusetts	Saxitoxin
1987-88	Bottlenose dolphins (645)	Eastern seaboard (New Jersey to Florida)	Morbillivirus; Brevetoxin
1987-88	Baikal seals (80-100,000)	Lake Baikal, Russia	Canine distemper virus
1988	Harbor seals (approx 18,000)	Northern Europe	Phocine distemper virus
1990	Striped dolphins (550)	Mediterranean Sea	Dolphin morbillivirus
1990	Bottlenose dolphins (146)	Gulf Coast, US	Unknown; unusual skin lesions observed

Year	Species and number	Location	Cause
1994	Bottlenose dolphins (72)	Texas	Morbillivirus
1995	California sea lions (222)	California	Leptospirosis
1996	Florida manatees (149)	West Coast Florida	Brevetoxin
1996	Bottlenose dolphins (30)	Mississippi	Unknown; Coincident with algal bloom
1997	Mediterranean monk seals (150)	Western Sahara, Africa	Harmful algal bloom; Morbillivirus
1997-98	California sea lions (100s)	California	El Nino
1998	California sea lions (70)	California	Domoic acid
1998	Hooker's sea lions (60% of pups)	New Zealand	Unknown, bacteria likely
1999	Harbor porpoises	Maine to North Carolina	Oceanographic factors suggested
2000	Caspian seals (10,000)	Caspian Sea	Canine distemper virus
1999-2000	Bottlenose dolphins (115)	Panhandle of Florida	Brevetoxin
1999-2001	Gray whales (651)	Canada, US West Coast, Mexico	Unknown; starvation involved
2000	California sea lions (178)	California	Leptospirosis
2000	California sea lions (184)	California	Domoic acid
2000	Harbor seals (26)	California	Unknown; Viral pneumonia suspected
2001	Bottlenose dolphins (35)	Florida	Unknown
2001	Harp seals (453)	Maine to Massachusetts	Unknown
2001	Hawaiian monk seals (11)	NW Hawaiian Islands	Malnutrition
2002	Harbor seals (approx. 25,000)	Northern Europe	Phocine distemper virus
2002	Multispecies (common dolphins, California sea lions, sea otters) (approx. 500)	California	Domoic acid
2002	Hooker's sea lions	New Zealand	Pneumonia
2002	Florida manatee	West Coast of Florida	Brevetoxin
2003	Multispecies (common dolphins, California sea lions, sea otters) (approx. 500)	California	Domoic acid
2003	Beluga whales (20)	Alaska	Ecological factors
2003	Sea otters	California	Ecological factors
2003	Large whales (16 humpback, 1 fine, 1 minke, 1 pilot, 2 unknown)	Maine	Unknown; Saxitoxin and domoic acid detected in 2 of 3 humpbacks
2003-2004	Harbor seals, minke whales	Gulf of Maine	Unknown
2003	Florida manatees (96)	West Coast of Florida	Brevetoxin
2004	Bottlenose dolphins (107)	Florida Panhandle	Brevetoxin
2004	Small cetaceans (67)	Virginia	Unknown
2004	Small cetaceans	North Carolina	Unknown
2004	California sea lions (405)	Canada, US West Coast	Leptospirosis

Year	Species and number	Location	Cause
2005	Florida manatees, bottlenose dolphins (ongoing Dec 2005)	West Coast of Florida	Brevetoxin
2005	Harbor porpoises	North Carolina	Unknown
2005	California sea lions; Northern fur seals	California	Domoic acid
2005	Large whales	Eastern North Atlantic	Domoic acid suspected
2005-2006	Bottlenose dolphins	Florida	Brevetoxin suspected

Note: Data from Gulland and Hall (2007): citations for each event contained in Gulland and Hall (2007).

H.2 UNITED STATES STRANDING RESPONSE ORGANIZATION

Stranding events provide scientists and resource manager's information not available from limited at-sea surveys, and may be the only way to learn key biological information about certain species such as distribution, seasonal occurrence, and health (Rankin, 1953; Moore et al., 2004; Geraci and Lounsbury, 2005). Necropsies are useful in attempting to determine a reason for the stranding, and are performed on stranded animals when the situation and resources allow.

In 1992, Congress passed the Marine Mammal Health and Stranding Response Act (MMHSRA) which authorized the Marine Mammal Health and Stranding Response Program (MMHSRP) under authority of the Department of Commerce, National Marine Fisheries Service. The MMHSRP was created because of public concern over marine mammal mortalities. Its objectives are twofold: to formalize the response process and to focus efforts being initiated by numerous local stranding organizations.

Major elements of the MMHSRP include the following (NMFS, 2007):

- National Marine Mammal Stranding Network
- Marine Mammal UME Program
- National Marine Mammal Tissue Bank (NMMTB) and Quality Assurance Program
- Marine Mammal Health Biomonitoring, Research, and Development
- Marine Mammal Disentanglement Network
- John H. Prescott Marine Mammal Rescue Assistance Grant Program (a.k.a. the Prescott Grant Program)
- Information Management and Dissemination.

The United States has a well-organized network in coastal states to respond to marine mammal strandings. Overseen by the NMFS, the National Marine Mammal Stranding Network is comprised of smaller organizations manned by professionals and volunteers from nonprofit organizations, aquaria, universities, and state and local governments trained in stranding response. Currently, more than 400 organizations are authorized by NMFS to respond to marine mammal strandings (NMFS, 2007).

The following is a list of NMFS Regions and Associated States and Territories:

- NMFS Northeast Region- ME, NH, MA, RI, CT, NY, NJ, PA, DE, MD, VA
- NMFS Southeast Region- NC, SC, GA, FL, AL, MS, LA, TX, PR, VI
- NMFS Southwest Region- CA
- NMFS Northwest Region- OR, WA
- NMFS Alaska Region- AK
- NMFS Pacific Islands Region- HI, Guam, American Samoa, Commonwealth of the Northern Mariana Islands (CNMI)

Stranding reporting and response efforts over time have been inconsistent, although effort and data quality within the United States have been improving within the last 20 years (NMFS, 2007). Given the historical inconsistency in response and reporting, however, interpretation of long-term trends in marine mammal stranding is difficult (NMFS, 2007). During the past decade (1995 to 2004), approximately 40,000 stranded marine mammals (about 12,400 were cetaceans) have been reported by the regional stranding networks, averaging 3,600 reported strandings per year (Figure H-1; NMFS, 2007). The highest number of strandings was reported between the years 1998 and 2003. Detailed regional stranding information including most commonly stranded species can be found in Zimmerman (1991), Geraci and Lounsbury (2005), and NMFS (2007).

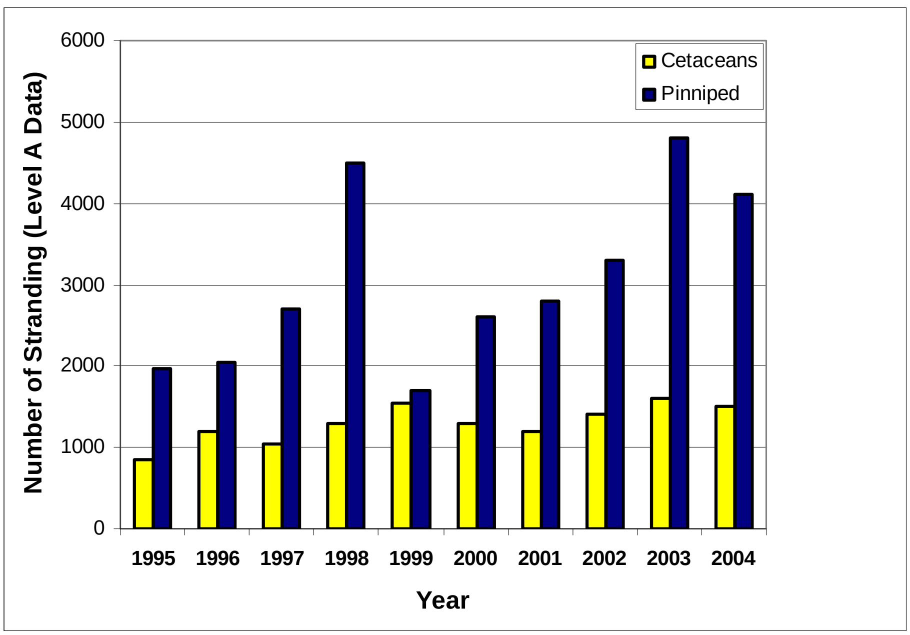


Figure H-1. United States annual cetacean and pinniped stranding events from 1995-2004.
(Source: NMFS 2007)

H.3 THREATS TO MARINE MAMMALS AND POTENTIAL CAUSES FOR STRANDING

Like any wildlife population, there are normal background mortality rates that influence marine mammal population dynamics, including starvation, predation, aging, reproductive success, and disease (Geraci et al., 1999; Carretta et al., 2007). Strandings may be reflective of this natural cycle or, more recently, may be the result of anthropogenic sources (i.e., human impacts). Current science suggests that multiple factors, both natural and man-made, may be acting alone or in combination to cause a marine mammal to strand (Geraci et al., 1999; Culik, 2002; Perrin and Geraci, 2002; Hoelzel, 2003; Geraci and Lounsbury, 2005; NRC, 2006). While post-stranding data collection and necropsies of dead animals are attempted in an effort to find a possible cause for the stranding, it is often difficult to pinpoint exactly one factor that is responsible for any given stranding. An animal suffering from one ailment becomes susceptible to various other influences because of its weakened condition, making it difficult to determine a primary cause. In many stranding cases, scientists never learn the exact reason for the stranding. Specific threats and potential stranding causes may include the following:

- Natural causes
  - Disease
  - Natural toxins
  - Weather and climatic influences
  - Navigation errors
  - Social cohesion
  - Predation

- Anthropogenic (human influenced) causes
  - Fisheries interaction
  - Vessel strike
  - Pollution and ingestion
  - Noise

H.4 NATURAL THREATS/STRANDING CAUSES

H.4.1 Overview

Significant natural causes of mortality, die-offs, and stranding discussed below include disease and parasitism; marine neurotoxins from algae; navigation errors that lead to inadvertent stranding; and climatic influences that impact the distribution and abundance of potential food resources (i.e., starvation). Other natural mortality not discussed in detail includes predation by other species such as sharks (Cockcroft et al., 1989; Heithaus, 2001), killer whales (Constantine et al., 1998; Guinet et al., 2000; Pitman et al., 2001), and some species of pinniped (Hiruki et al., 1999; Robinson et al., 1999).

H.4.2 Disease

Like other mammals, marine mammals frequently suffer from a variety of diseases of viral, bacterial, and fungal origin (Visser et al., 1991; Dunn et al., 2001; Harwood, 2002). Gulland and

Hall (2005; 2007) provide a more detailed summary of individual and population effects of marine mammal diseases.

Microparasites such as bacteria, viruses, and other microorganisms are commonly found in marine mammal habitats and usually pose little threat to a healthy animal (Geraci et al., 1999). For example, long-finned pilot whales that inhabit the waters off of the northeastern coast of the United States are carriers of the morbillivirus, yet have grown resistant to its usually lethal effects (Geraci et al., 1999). Since the 1980s, however, virus infections have been strongly associated with marine mammal die-offs (Domingo et al., 1992; Geraci and Lounsbury, 2005). Morbillivirus is the most significant identified marine mammal virus and suppresses a host's immune system and increases risk of secondary infection (Harwood, 2002). The largest bottlenose dolphin die-off associated with morbillivirus occurred in 1987, when hundreds of coastal dolphins succumbed to the virus (Lipscomb et al., 1994). A bottlenose dolphin UME in 1993 and 1994 was caused by morbillivirus. Die-offs ranged from northwestern Florida to Texas, with an increased number of deaths as it spread (NMFS, 2007). A 2004 UME in Florida was also associated with dolphin morbillivirus (NMFS, 2004). Influenza A was responsible for the first reported mass mortality in the U.S., occurring along the coast of New England in 1979-1980 (Geraci et al., 1999; Harwood, 2002). Canine distemper virus has been responsible for large scale pinniped mortalities and die-offs (Grachev et al., 1989; Kennedy et al., 2000; Gulland and Hall, 2005), while a bacteria, *Leptospira pomona*, is responsible for periodic die-offs in California sea lions about every four years (Gulland et al., 1996; Gulland and Hall, 2005). It is difficult to determine whether microparasites commonly act as a primary pathogen, or whether they show up as a secondary infection in an already weakened animal (Geraci et al., 1999). Most marine mammal die-offs from infectious disease in the last 25 years, however, have had viruses associated with them (Simmonds and Mayer, 1997; Geraci et al., 1999; Harwood, 2002).

Macroparasites are usually large parasitic organisms and include lungworms, trematodes (parasitic flatworms), and protozoans (Geraci and St.Aubin, 1987; Geraci et al., 1999). Marine mammals can carry many different types, and have shown a robust tolerance for sizeable infestation unless compromised by illness, injury, or starvation (Morimitsu et al., 1987; Dailey et al., 1991; Geraci et al., 1999). *Nasitrema spp.*, a usually benign trematode found in the head sinuses of cetaceans (Geraci et al., 1999), can cause brain damage if it migrates (Ridgway and Dailey, 1972). As a result, this worm is one of the few directly linked to stranding in the cetaceans (Dailey and Walker, 1978; Geraci et al., 1999).

Non-infectious disease, such as congenital bone pathology of the vertebral column (osteomyelitis, spondylosis deformans, and ankylosing spondylitis), has been described in several species of cetacean (Paterson, 1984; Alexander et al., 1989; Kompanje, 1995; Sweeny et al., 2005). In humans, bone pathology such as ankylosing spondylitis, can impair mobility and increase vulnerability to further spinal trauma (Resnick and Niwayama, 2002). Bone pathology has been found in cases of single strandings (Paterson, 1984; Kompanje, 1995), and also in cetaceans prone to mass stranding (Sweeny et al., 2005), possibly acting as a contributing or causal influence in both types of events.

H.4.3 Naturally Occurring Marine Neurotoxins

Some single cell marine algae common in coastal waters, such as dinoflagellates and diatoms, produce toxic compounds that can accumulate (termed bioaccumulation) in the flesh and organs of fish and invertebrates (Geraci et al., 1999; Harwood, 2002). Marine mammals become exposed to these compounds when they eat prey contaminated by these naturally produced toxins (Van Dolah, 2005). Figure H-2 shows U.S. animal mortalities from 1997-2006 resulting from toxins produced during harmful algal blooms.

In the Gulf of Mexico and mid- to southern Atlantic states, "red tides," a form of harmful algal bloom, are created by a dinoflagellate (*Karenia brevis*). *K. brevis* is found throughout the Gulf of Mexico and sometimes along the Atlantic coast (Van Dolah, 2005; NMFS, 2007). It produces a neurotoxin known as brevetoxin. Brevetoxin has been associated with several marine mammal UMEs within this area (Geraci, 1989; Van Dolah et al., 2003; NMFS, 2004; Flewelling et al., 2005; Van Dolah, 2005; NMFS, 2007). On the U.S. West Coast and in the northeast Atlantic, several species of diatoms produce a toxin called domoic acid which has also been linked to marine mammal strandings (Geraci et al., 1999; Van Dolah et al., 2003; Greig et al., 2005; Van Dolah, 2005; Brodie et al., 2006; NMFS, 2007). Other algal toxins associated with marine mammal strandings include saxitoxins and ciguatoxins and are summarized by Van Dolah (2005).

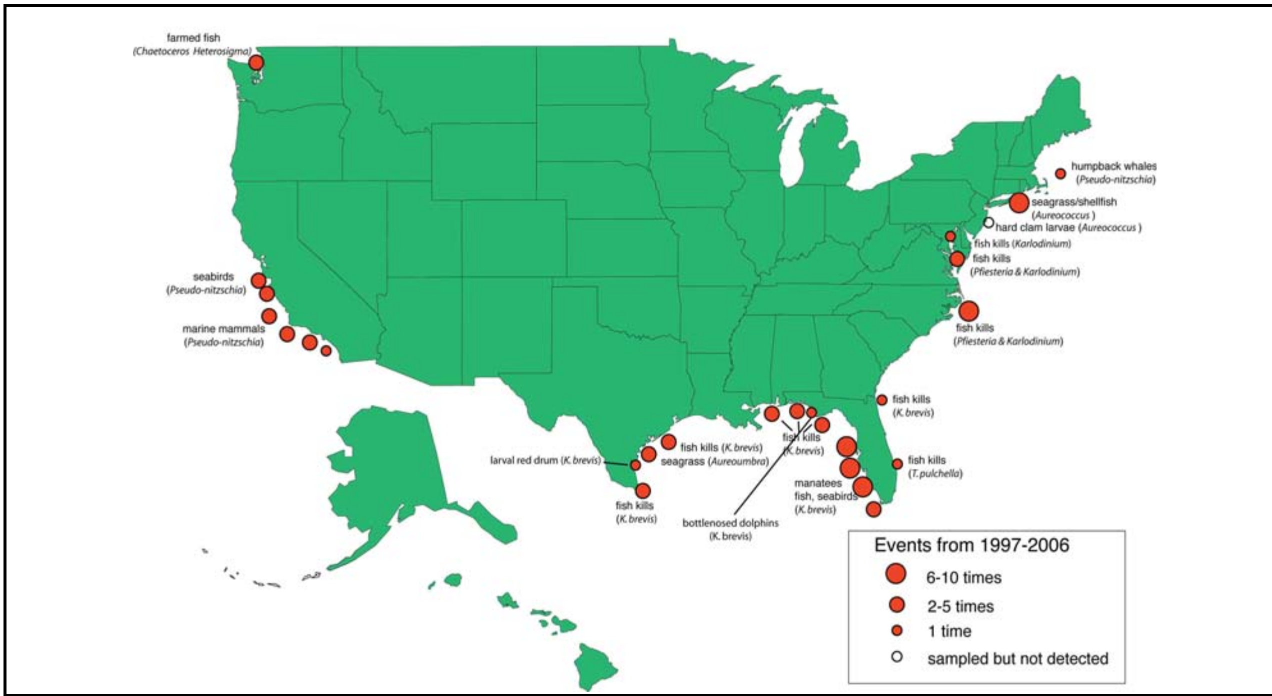


Figure H-2. Animal Mortalities from harmful algal blooms within the United States from 1997-2006.
(Source: Woods Hole Oceanographic Institute (WHO) http://www.whoi.edu/redtide/HABdistribution/HABmap.html)

H.4.4 Weather events and climate influences

Severe storms, hurricanes, typhoons, and prolonged temperature extremes may lead to localized marine mammal strandings (Geraci et al., 1999; Walsh et al., 2001). Hurricanes may have been responsible for mass strandings of pygmy killer whales in the British Virgin Islands and Gervais' beaked whales in North Carolina (Mignucci-Giannoni et al., 2000; Norman and Mead, 2001). Storms in 1982-1983 along the California coast led to deaths of 2,000 northern elephant seal pups (Le Boeuf and Reiter, 1991). Ice movement along southern Newfoundland has forced groups of blue whales and white-beaked dolphins ashore (Sergeant, 1982). Seasonal oceanographic conditions in terms of weather, frontal systems, and local currents may also play a role in stranding (Walker et al., 2005).

The effect of large scale climatic changes to the world's oceans and how these changes impact marine mammals and influence strandings is difficult to quantify given the broad spatial and temporal scales involved, and the cryptic movement patterns of marine mammals (Moore, 2005; Learmonth et al., 2006). The most immediate, although indirect, effect is decreased prey availability during unusual conditions. This, in turn, results in increased search effort required by marine mammals (Crocker et al., 2006) and potential starvation if foraging is not successful. Stranding may follow either as a direct result of starvation or as an indirect result of a weakened and stressed state (e.g., succumbing to disease) (Selzer and Payne, 1988; Geraci et al., 1999; Moore, 2005; Learmonth et al., 2006; Weise et al., 2006).

Two recent papers examined potential influences of climate fluctuation on stranding events in southern Australia, including Tasmania, an area with a history of more than 20 mass strandings since the 1920s (Evans et al., 2005; Bradshaw et al., 2006). These authors note that patterns in animal migration, survival, fecundity, population size, and strandings will revolve around the availability and distribution of food resources. In southern Australia, movement of nutrient-rich waters pushed closer to shore by periodic meridional winds (occurring about every 12 to 14 years) may be responsible for bringing marine mammals closer to land, thus increasing the probability of stranding (Bradshaw et al., 2006). The papers conclude, however, that while an overarching model can be helpful for providing insight into the prediction of strandings, the particular reasons for each one are likely to be quite varied.

H.4.5 Navigational Error

Geomagnetism- It has been hypothesized that, like some land animals, marine mammals may be able to orient to the Earth's magnetic field as a navigational cue, and that areas of local magnetic anomalies may influence strandings (Bauer et al., 1985; Klinowska, 1985; Kirschvink et al., 1986; Klinowska, 1986; Walker et al., 1992; Wartzok and Ketten, 1999). In a plot of live stranding positions in Great Britain with magnetic field maps, Klinowska (1985, 1986) observed an association between live stranding positions and magnetic field levels. In all cases, live strandings occurred at locations where magnetic minima, or lows in the magnetic fields, intersect the coastline. Kirschvink et al. (1986) plotted stranding locations on a map of magnetic data for the East Coast, and were able to develop associations between stranding sites and locations where magnetic minima intersected the coast. The authors concluded that there were highly significant tendencies for cetaceans to beach themselves near these magnetic minima and coastal intersections. The results supported the hypothesis that cetaceans may have a magnetic sensory system similar to other migratory animals, and that marine magnetic topography and patterns may influence long-distance movements (Kirschvink et al., 1986). Walker et al. (1992) examined fin whale swim patterns off the northeastern U.S. continental shelf, and reported that migrating animals aligned with lows in the gradient of magnetic intensity. While a similar pattern between magnetic features and marine mammal strandings at New Zealand stranding sites was not seen (Brabyn and Frew, 1994), mass strandings in Hawaii typically were found to occur within a narrow range of magnetic anomalies (Mazzuca et al., 1999).

Echolocation Disruption in Shallow Water- Some researchers believe stranding may result from reductions in the effectiveness of echolocation within shallow water, especially with the pelagic species of odontocetes who may be less familiar with coastline (Dudok van Heel, 1966; Chambers and James, 2005). For an odontocete, echoes from echolocation signals contain important information on the location and identity of underwater objects and the shoreline. The authors postulate that the gradual slope of a beach may present difficulties to the navigational systems of some cetaceans, since it is common for live strandings to occur along beaches with shallow, sandy gradients (Brabyn and McLean, 1992; Mazzuca et al., 1999; Maldini et al., 2005; Walker et al., 2005). A contributing factor to echolocation interference in turbulent, shallow water is the presence of microbubbles from the interaction of wind, breaking waves, and currents. Additionally, ocean water near the shoreline can have an increased turbidity (e.g., floating sand or silt, particulate plant matter, etc.) due to the run-off of fresh water into the ocean, either from rainfall or from freshwater outflows (e.g., rivers and creeks). Collectively, these factors can reduce and scatter the sound energy within echolocation signals and reduce the perceptibility of returning echoes of interest.

H.4.6 Social cohesion

Many pelagic species such as sperm whales, pilot whales, melon-head whales, and false killer whales, and some dolphins occur in large groups with strong social bonds between individuals. When one or more animals strand due to any number of causative events, then the entire pod may follow suit out of social cohesion (Geraci et al., 1999; Conner, 2000; Perrin and Geraci, 2002; NMFS, 2007).

H.5 ANTHROPOGENIC THREATS/STRANDING CAUSES

H.5.1 Overview

With the exception of historic whaling in the 19th and early part of the 20th century, during the past few decades there has been an increase in marine mammal mortalities associated with a variety of human activities (Geraci et al., 1999; NMFS, 2007). These include fisheries interactions (bycatch and directed catch), pollution (marine debris, toxic compounds), habitat modification (degradation, prey reduction), vessel strikes (Laist et al., 2001), and gunshots. Figure H-3 shows potential worldwide risk to small-toothed cetaceans by source.

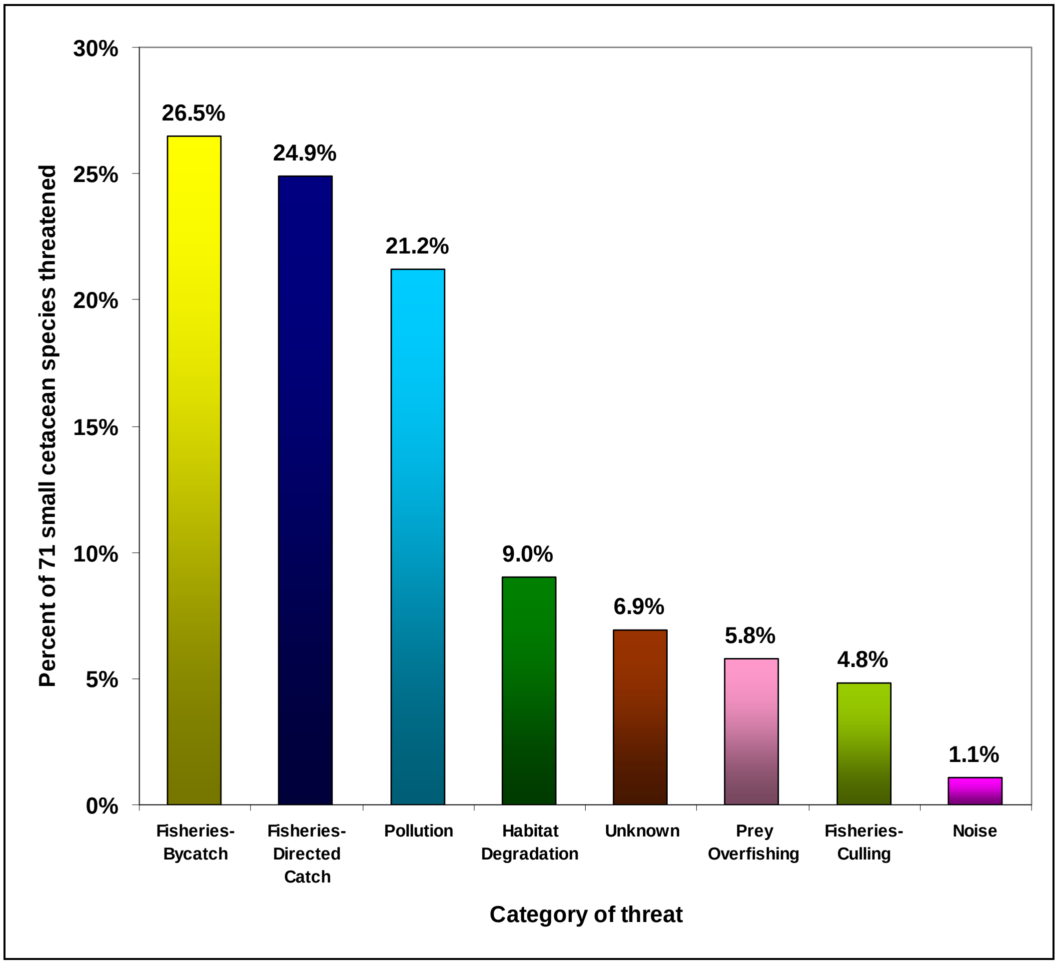


Figure H-3. Human threats to world wide small cetacean populations.
(Source: Culik 2002)

H.5.2 Fisheries Interaction: By-Catch and Entanglement

The incidental catch of marine mammals in commercial fisheries is a significant threat to the survival and recovery of many populations of marine mammals (Geraci et al., 1999; Baird, 2002; Culik, 2002; Carretta et al., 2004; Geraci and Lounsbury, 2005; NMFS, 2007). Interactions with fisheries and entanglement in discarded or lost gear continue to be a major factor in their deaths worldwide (Geraci et al., 1999; Nieri et al., 1999; Geraci and Lounsbury, 2005; Read et al., 2006; Zeeber et al., 2006).

By-catch- By-catch is the catching of non-target species within a given fishing operation and can include non-commercially used invertebrates, fish, sea turtles, birds, and marine mammals (NRC, 2006). Read et al. (2006) estimated the magnitude of marine mammal by-catch in U.S. and global fisheries. Data for the United States was obtained from fisheries observer programs, reports of entangled stranded animals, and fishery logbooks. In U.S. fisheries, the mean annual by-catch of marine mammals between 1990 and 1999 was 6,215 animals (SE = +/- 448). Eighty-four percent of cetacean by-catch occurred in gill-net fisheries, with dolphins and porpoises constituting the majority of these. The authors noted a 40 percent decline in marine mammal by-catching the years 1995 through 1999 compared to 1990 through 1994, and suggested that effective conservation measures implemented during the later time period played a significant role.

To estimate annual global by-catch, Read et al. (2006) used U.S. vessel by-catch data from 1990-1994 and extrapolated to the world's vessels for the same time period. They calculated an estimate of 653,365 of marine mammals caught annually around the world, again with most occurring in gill-net fisheries. The authors concluded that with global marine mammal by-catch likely to be in the hundreds of thousands every year, by-catch in fisheries will be the single greatest threat to many marine mammal populations around the world.

Entanglement- Active and discarded fishing gear pose a major threat to marine mammals. Entanglement can lead to drowning and/or impairment in activities such as diving, swimming, feeding and breeding. Stranded marine mammals frequently exhibit signs of previous fishery interaction, such as scarring or gear still attached to their bodies, and the cause of death for many stranded marine mammals is often attributed to such interactions (Baird and Gorgone, 2005; Geraci et al., 1999; Campagna et al., 2007). Because marine mammals that die or are injured in fisheries may not wash ashore and not all animals that do wash ashore exhibit clear signs of interactions, stranding data probably underestimate fishery-related mortality and serious injury (NMFS, 2005a).

Various accounts of fishery-related stranding deaths have been reported over the last several decades along the U.S. coast. From 1993 through 2003, 1,105 harbor porpoises were reported stranded from Maine to North Carolina, many of which had cuts and body damage suggestive of net entanglement (NMFS, 2005d). In 1999, it was possible to determine that the cause of death for 38 of the stranded porpoises was from fishery interactions (NMFS, 2005d). An estimated 78 baleen whales were killed annually in the offshore southern California/Oregon drift gillnet fishery during the 1980s (Heyning and Lewis 1990). From 1998-2005, based on observer records, five fin whales (CA/OR/WA stock), 12 humpback whales (ENP stock), and six sperm whales (CA/OR/WA stock) were either seriously injured or killed in fisheries off the mainland U.S. West Coast (California Marine Mammal Stranding Network Database 2006).

H.5.3 Ship Strike

Marine mammals sometimes come into physical contact with oceangoing vessels, which can lead to injury or death and cause subsequent stranding (Laist et al. 2001; Geraci and Lounsbury, 2005; de Stephanis and Urquiola, 2006). These events, termed "ship strikes," occur when an animal at the surface is struck directly by a vessel, when a surfacing animal hits the bottom of a vessel, or when an animal just below the surface is cut by a vessel's propeller. The severity of injuries typically depends on the size and speed of the vessel (Knowlton and Kraus, 2001; Laist et al., 2001; Vanderlaan and Taggart 2007).

The growth in civilian commercial ports has been accompanied by a large increase in commercial vessel traffic. This has, in turn, expanded the threat of ship strikes to marine mammals in recent decades. The Final Report of the NOAA International Symposium on "Shipping Noise and Marine Mammals: A Forum for Science, Management, and Technology" stated that the worldwide commercial fleet has grown from approximately 30,000 vessels in 1950 to over 85,000 vessels in 1998 (NRC, 2003; Southall, 2005). From 1985 to 1999, world seaborne trade doubled to 5 billion tons and currently includes 90 percent of the total world trade, with container shipping movements representing the largest volume of seaborne trade. Current statistics support the prediction that the international shipping fleet will continue to grow at current or greater rates. Vessel densities along existing coastal routes are expected to increase both domestically and internationally. New routes are expected to develop as new ports are opened and existing ports are expanded. Vessel propulsion systems are also advancing toward faster ships operating in higher sea states for lower operating costs; and container ships are expected to become larger along certain routes (Southall, 2005). Given the expected increase in vessel density and operational capability, a concomitant increase in marine mammal ship strikes can be expected.

H.5.4 Ingestion of Marine Debris and Exposure to Toxins

Debris in the marine environment poses a health hazard for marine mammals. Not only can they become entangled, but animals may ingest plastics and other debris that are indigestible, and which can contribute to illness or death through irritation or blockage of the stomach and intestines (Tarpley and Marwitz, 1993, Whitaker et al., 1994; Gorzelany, 1998; Secchi and Zarzur, 1999; Baird and Hooker, 2000). There are certain species of cetaceans (e.g. sperm whales) that are more likely to eat trash, especially plastics (Geraci et al., 1999; Evans et al., 2003; Whitehead, 2003).

For example, between 1990 and October 1998, 215 pygmy sperm whales stranded along the U.S. Atlantic coast from New York through the Florida Keys (NMFS, 2005a). Remains of plastic bags and other debris were found in the stomachs of 13 of these animals. In 1987, a pair of latex examination gloves was retrieved from the stomach of a stranded dwarf sperm whale (NMFS, 2005c). In one pygmy sperm whale found stranded in 2002, red plastic debris was found in the stomach along with squid beaks (NMFS, 2005a). Oliveira de Meirelles and Barros (2007) documented mortality to a rough-toothed dolphin in Brazil from plastic debris ingestion.

Chemical contaminants like organochlorines (PCBs, DDT) and heavy metals may pose potential health risks to marine mammals (Das et al., 2003; De Guise et al., 2003).Despite having been banned for decades, levels of organochlorines are still high in marine mammal tissue samples taken along U.S. coasts (Hickie et al. 2007; Krahn et al. 2007; NMFS, 2007a). These compounds are long-lasting, reside in marine mammal adipose tissues (especially in the blubber), and can be toxic. Contaminant levels in odontocetes (piscivorous animals) have been reported to be one to two orders of magnitude higher compared to mysticetes (planktivorous animals) (Borell, 1993; O'Shea and Brownell, 1994; O'Hara and Rice, 1996; O'Hara et al., 1999).

Chronic exposure to PCBs and/or DDT is immunosuppressive, as has been seen in bottlenose dolphins (Lahvis et al., 1995) and seals (p. vitulina) (Ross et al., 1996). Chronic exposure has been linked to infectious disease mortality in harbor porpoises stranded in the UK (Jepson et al., 1999; Jepson et al., 2005), carcinoma in California in sea lions (Ylitalo et al., 2005), and population reductions of Baltic seals (Bergman et al., 2001). High levels of PCBs in immature, pelagic dolphins has been observed (Struntz et al., 2004), raising concern about contaminant loads further offshore. Moderate levels of PCBs and chlorinated pesticides (such as DDT, DDE, and dieldrin) have been found in pilot whale blubber with bioaccumulation levels more similar in whales from the same stranding event than from animals of the same age or sex (NMFS, 2005b). Accumulation of heavy metals has also been documented in many cetaceans (Frodello and Marchand, 2001; Das et al., 2003; Wittnich et al., 2004), sometimes exceeding levels known to cause neurologic and immune system impairment in other mammals (Nielsen et al., 2000; Das et al., 2003; De Guise et al., 2003).

Other forms of habitat contamination and degradation may also play a role in marine mammal mortality and strandings. Some events caused by humans have direct and obvious effects on marine mammals, such as oil spills (Geraci et al., 1999). Oil spills can cause both short- and long-term medical problems for many marine mammal species through ingestion of tainted prey, coating of skin/fur, and adherence to oral and nasal cavities (Moeller, 2003). In most cases, the effects of contamination are likely to be indirect in nature; e.g. effects on prey species availability or an increase in disease susceptibility (Geraci et al., 1999).

H.5.5 Anthropogenic Sound

There is evidence that underwater man-made sounds, such as explosions, drilling, construction, and certain types of sonar (Southall et al., 2006), may be a contributing factor in some stranding events. Marine mammals may respond both behaviorally and physiologically to anthropogenic sound exposure, (e.g., Richardson et al., 1995; Finneran et al., 2000; Finneran et al., 2003; Finneran et al., 2005); however, the range and magnitude of the behavioral response of marine mammals to various sound sources is highly variable (Richardson et al., 1995) and appears to depend on the species involved, the experience of the animal with the sound source, the motivation of the animal (e.g., feeding, mating), and the context of the exposure.

Exposure to sonar signals has been postulated as being a specific cause of several stranding events. Given that it is likely that the frequency of certain sonar systems is within the range of hearing of many marine mammals, the consideration of sonar as a causative mechanism of stranding is warranted. In the following sections, specific stranding events that have been putatively linked to sonar operations are discussed.

H.6 STRANDING EVENT CASE STUDIES

Over the past two decades, several mass stranding events involving beaked whales have been documented. A review of historical data (mostly anecdotal) maintained by the Marine Mammal Program in the National Museum of Natural History, Smithsonian Institution reports 49 beaked whale mass stranding events between 1838 and 1999. The largest beaked whale mass stranding occurred in the 1870s in New Zealand when 28 Gray's beaked whales (*Mesoplodon grayi*) stranded. Blainsville's beaked whale (*Mesoplodon densirostris*) strandings are rare, and records show that they were involved in one mass stranding in 1989 in the Canary Islands. Cuvier's beaked whales (*Ziphius cavirostris*) are the most frequently reported beaked whale to strand, with at least 19 stranding events from 1804 through 2000 (DoC and DoN, 2001; Smithsonian Institution, 2000). While beaked whale strandings have occurred since the 1800s (Geraci and Lounsbury, 1993; Cox et al., 2006; Podesta et al., 2006), several mass strandings have been temporally and spatially associated with naval operations utilizing mid-frequency active (MFA) sonar (Simmonds and Lopez-Jurado, 1991; Frantzis, 1998; Jepson et al., 2003; Cox et al., 2006).

H.6.1 Beaked Whale Case Studies

In the following sections, specific stranding events that have been putatively linked to potential sonar operations are discussed. These events represent a small overall number of animals over an 11 year period (40 animals) and not all worldwide beaked whale strandings can be linked to naval activity (ICES, 2005a; 2005b; Podesta et al., 2006). Four of the five events occurred during NATO exercises or events where DON presence was limited (Greece, Portugal, and Spain). One of the five events involved only DON ships (Bahamas). These events are given specific consideration in the case studies that follow.

Beaked whale stranding events associated with naval operations.

1996	May	Greece (NATO/US)
2000	March	Bahamas (US)
2000	May	Portugal, Madeira Islands (NATO/US)
2002	September	Spain, Canary Islands (NATO/US)
2006	January	Spain, Mediterranean Sea coast (NATO/US)

1996 Greece Beaked Whale Mass Stranding (May 12 – 13, 1996)

Description: Twelve Cuvier's beaked whales (*Ziphius cavirostris*) stranded along a 38.2-km (20.6-NM) strand of the coast of the Kyparissiakos Gulf on May 12 and 13, 1996 (Frantzis, 1998). From May 11 through May 15, the NATO research vessel Alliance was conducting sonar tests with signals of 600 Hz and 3 kHz and root-mean-squared (rms) sound pressure levels (SPL) of 228 and 226 dB re: 1 µPa, respectively (D'Amico and Verboom, 1998; D'Spain et al., 2006). The timing and the location of the testing encompassed the time and location of the whale strandings (Frantzis, 1998).

Findings: Partial necropsies of eight of the animals were performed, including external assessments and the sampling of stomach contents. No abnormalities attributable to acoustic exposure were observed, but the stomach contents indicated that the whales were feeding on cephalods soon before the stranding event. No unusual environmental events before or during the stranding event could be identified (Frantzis, 1998).

Conclusions: The timing and spatial characteristics of this stranding event were atypical of stranding in Cuvier's beaked whale, particularly in this region of the world. No natural phenomenon that might contribute to the stranding event coincided in time with the mass stranding. Because of the rarity of mass strandings in the Greek Ionian Sea, the probability that the sonar tests and stranding coincided in time and location, while being independent of each other, was estimated as being extremely low (Frantzis, 1998). However, because information for the necropsies was incomplete and inconclusive, the cause of the stranding cannot be precisely determined.

2000 Bahamas Marine Mammal Mass Stranding (March 15-16, 2000)

Description: Seventeen marine mammals comprised of nine Cuvier's beaked whales, three Blainville's beaked whales (*Mesoplodon densirostris*), two unidentified beaked whales, two minke whales (*Balaenoptera acutorostrata*), and one spotted dolphin (*Stenella frontalis*), stranded along the Northeast and Northwest Providence Channels of the Bahamas Islands on March 15-16, 2000 (Evans and England, 2001). The strandings occurred over a 36-hour period and coincided with DON use of mid-frequency active sonar within the channel. Navy ships were involved in tactical sonar exercises for approximately 16 hours on March 15. The ships, which operated the AN/SQS-53C and AN/SQS-56, moved through the channel while emitting sonar pings approximately every 24 seconds. The timing of pings was staggered between ships and average source levels of pings varied from a nominal 235 dB SPL (AN/SQS-53C) to 223 dB SPL (AN/SQS-56). The center frequency of pings was 3.3 kHz and 6.8 to 8.2 kHz, respectively.

Seven of the animals that stranded died, while ten animals were returned to the water alive. The animals known to have died included five Cuvier's beaked whales, one Blainville's beaked whale, and the single spotted dolphin. Six necropsies were performed and three of the six necropsied whales (one Cuvier's beaked whale, one Blainville's beaked whale, and the spotted dolphin) were fresh enough to permit identification of pathologies by computerized tomography (CT). Tissues from the remaining three animals were in a state of advanced decomposition at the time of inspection.

Findings: All five necropsied beaked whales were in good body condition and did not show any signs of external trauma or disease. In the two best preserved whale specimens, hemorrhage was associated with the brain and hearing structures. Specifically, subarachnoid hemorrhage within the temporal region of the brain and intracochlear hemorrhages were noted. Similar findings of bloody effusions around the ears of two other moderately decomposed whales were consistent with the same observations in the freshest animals. In addition, three of the whales had small hemorrhages in their acoustic fats, which are fat bodies used in sound production and reception (i.e., fats of the lower jaw and the melon). The best-preserved whale demonstrated acute hemorrhage within the kidney, inflammation of the lung and lymph nodes, and congestion and mild hemorrhage in multiple other organs.

Other findings were consistent with stresses and injuries associated with the stranding process. These consisted of external scrapes, pulmonary edema and congestion. The spotted dolphin demonstrated poor body condition and evidence of a systemic debilitating disease. In addition, since the dolphin stranding site was isolated from the acoustic activities of Navy ships, it was determined that the dolphin stranding was unrelated to the presence of Navy active sonar.

Conclusions: The post-mortem analyses of stranded beaked whales led to the conclusion that the immediate cause of death resulted from overheating, cardiovascular collapse and stresses associated with being stranded on land. However, the presence of subarachnoid and intracochlear hemorrhages were believed to have occurred prior to stranding and were hypothesized as being related to an acoustic event. Passive acoustic monitoring records demonstrated that no large scale acoustic activity besides the Navy sonar exercise occurred in the times surrounding the stranding event. The mechanism by which sonar could have caused the observed traumas or caused the animals to strand was undetermined. The spotted dolphin was in overall poor condition for examination, but showed indications of long-term disease. No analysis of baleen whales (minke whale) was conducted.

2000 Madeira Island, Portugal Beaked Whale Strandings (May 10 – 14, 2000)

Description: Three Cuvier's beaked whales stranded on two islands in the Madeira Archipelago, Portugal, from May 10–14, 2000 (Cox et al., 2006). A joint NATO amphibious training exercise, named "Linked Seas 2000," which involved participants from 17 countries, took place in Portugal during May 2–15, 2000. The timing and location of the exercises overlapped with that of the stranding incident.

Findings: Two of the three whales were necropsied. Two heads were taken to be examined. One head was intact and examined grossly and by CT; the other was only grossly examined because it was partially flensed and had been seared from an attempt to dispose of the whale by fire (Ketten, 2005). No blunt trauma was observed in any of the whales. Consistent with prior CT scans of beaked whales stranded in the Bahamas 2000 incident, one whale demonstrated subarachnoid and peribullar hemorrhage and blood within one of the brain ventricles. Post-cranially, the freshest whale demonstrated renal congestion and hemorrhage, which was also consistent with findings in the freshest specimens in the Bahamas incident.

Conclusions: The pattern of injury to the brain and auditory system were similar to those observed in the Bahamas strandings, as were the kidney lesions and hemorrhage and congestion in the lungs (Ketten, 2005). The similarities in pathology and stranding patterns between these two events suggested a similar causative mechanism. Although the details about whether or how sonar was used during "Linked Seas 2000" is unknown, the presence of naval activity within the region at the time of the strandings suggested a possible relationship to Navy activity.

2002 Canary Islands Beaked Whale Mass Stranding (24 September 2002)

Description: On September 24, 2002, 14 beaked whales stranded on Fuerteventura and Lanzaote Islands in the Canary Islands (Jepson et al., 2003). Seven of the 14 whales died on the beach and the 7 were returned to the ocean. Four beaked whales were found stranded dead over the next three days either on the coast or floating offshore (Fernández et al., 2005). At the time of the strandings, an international naval exercise called Neo-Tapon, involving numerous surface warships and several submarines was being conducted off the coast of the Canary Islands. Tactical mid-frequency active sonar was utilized during the exercises, and strandings began within hours of the onset of the use of mid-frequency sonar (Fernández et al., 2005).

Findings: Eight Cuvier's beaked whales, one Blainville's beaked whale, and one Gervais' beaked whale were necropsied; six of them within 12 hours of stranding (Fernández et al., 2005). The stomachs of the whales contained fresh and undigested prey contents. No pathogenic bacteria were isolated from the whales, although parasites were found in the kidneys of all of the animals. The head and neck lymph nodes were congested and hemorrhages were noted in multiple tissues and organs, including the kidney, brain, ears, and jaws. Widespread fat emboli were found throughout the carcasses, but no evidence of blunt trauma was observed in the whales. In addition, the parenchyma of several organs contained macroscopic intravascular bubbles and lesions, putatively associated with nitrogen off-gassing.

Conclusions: The association of NATO mid-frequency sonar use close in space and time to the beaked whale strandings, and the similarity between this stranding event and previous beaked whale mass strandings coincident with sonar use, suggests that a similar scenario and causative mechanism of stranding may be shared between the events. Beaked whales stranded in this event demonstrated brain and auditory system injuries, hemorrhages, and congestion in multiple organs, similar to the pathological findings of the Bahamas and Madeira stranding events. In addition, the necropsy results of Canary Islands stranding event lead to the hypothesis that the presence of disseminated and widespread gas bubbles and fat emboli were indicative of nitrogen bubble formation, similar to what might be expected in decompression sickness (Jepson et al., 2003; Fernández et al., 2005). Whereas gas emboli would develop from the nitrogen gas, fat emboli would enter the blood stream from ruptured fat cells (presumably where nitrogen bubble formation occurs) or through the coalescence of lipid bodies within the blood stream.

The possibility that the gas and fat emboli found by Fernández et al. (2005) was due to nitrogen bubble formation has been hypothesized to be related to either direct activation of the bubble by sonar signals or to a behavioral response in which the beaked whales flee to the surface following sonar exposure. The first hypothesis is related to rectified diffusion (Crum and Mao, 1996), the process of increasing the size of a bubble by exposing it to a sound field. This process is facilitated if the environment in which the ensonified bubbles exist is supersaturated with gas. Repetitive diving by marine mammals can cause the blood and some tissues to accumulate gas to a greater degree than is supported by the surrounding environmental pressure (Ridgway and Howard, 1979). Deeper and longer dives of some marine mammals, such as those conducted by beaked whales, are theoretically predicted to induce greater levels of supersaturation (Houser et al., 2001). If rectified diffusion were possible in marine mammals exposed to high-level sound, conditions of tissue supersaturation could theoretically speed the rate and increase the size of bubble growth. Subsequent effects due to tissue trauma and emboli would presumably mirror those observed in humans suffering from decompression sickness.

It is unlikely that the short duration of sonar pings would be long enough to drive bubble growth to any substantial size, if such a phenomenon occurs. However, an alternative but related hypothesis has also been suggested: stable bubbles could be destabilized by high-level sound exposures such that bubble growth then occurs through static diffusion of gas out of the tissues. In such a scenario the marine mammal would need to be in a gas-supersaturated state for a long enough period of time for bubbles to become of a problematic size. The second hypothesis speculates that rapid ascent to the surface following exposure to a startling sound might produce tissue gas saturation sufficient for the evolution of nitrogen bubbles (Jepson et al., 2003; Fernández et al., 2005). In this scenario, the rate of ascent would need to be sufficiently rapid to compromise behavioral or physiological protections against nitrogen bubble formation.

Although theoretical predictions suggest the possibility for acoustically mediated bubble growth, there is considerable disagreement among scientists as to its likelihood (Piantadosi and Thalmann, 2004). Sound exposure levels predicted to cause in vivo bubble formation within diving cetaceans have not been evaluated and are suspected as needing to be very high (Evans, 2002; Crum et al., 2005). Further, although it has been argued that traumas from recent beaked whale strandings are consistent with gas emboli and bubble-induced tissue separations (Jepson et al., 2003), there is no conclusive evidence supporting this hypothesis and there is concern that at least some of the pathological findings (e.g., bubble emboli) are artifacts of the necropsy. Currently, stranding networks in the United States have created a set of necropsy guidelines to determine, in part, the possibility and frequency with which bubble emboli can be introduced into marine mammals during necropsy procedures (Arruda et al., 2007).

2006 Spain, Gulf of Vera Beaked Whale Mass Stranding (26-27 January 2006)

Description: The Spanish Cetacean Society reported an atypical mass stranding of four beaked whales that occurred January 26, 2006, on the southeast coast of Spain near Mojacar (Gulf of Vera) in the Western Mediterranean Sea. According to the report, two of the whales were discovered the evening of January 26 and were found to be still alive. Two other whales were discovered during the day on January 27, but had already died. A following report stated that the first three animals were located near the town of Mojacar and were examined by a team from the University of Las Palmas de Gran Canarias, with the help of the stranding network of Ecologistas en Acción Almería-PROMAR and others from the Spanish Cetacean Society. The fourth animal was found dead on the afternoon of May 27, a few kilometers north of the first three animals.

From January 25-26, 2006, a NATO surface ship group (seven ships including one U.S. ship under NATO operational command) conducted active sonar training against a Spanish submarine within 93 km (50 NM) of the stranding site.

Findings: Veterinary pathologists necropsied the two male and two female beaked whales (*Z. cavirostris*).

Conclusions: According to the pathologists, a likely cause of this type of beaked whale mass stranding event may have been anthropogenic acoustic activities. However, no detailed pathological results confirming this supposition have been published to date, and no positive acoustic link was established as a direct cause of the stranding.

Even though no causal link can be made between the stranding event and naval exercises, certain conditions may have existed in the exercise area that, in their aggregate, may have contributed to the marine mammal strandings (Freitas, 2004):

- Operations were conducted in areas of at least 1,000 m (3,281 ft) in depth near a shoreline where there is a rapid change in bathymetry on the order of 1,000 to 6,000 m (3,281 to 19,685 ft) occurring a cross a relatively short horizontal distance (Freitas, 2004).
- Multiple ships, in this instance, five MFA sonar equipped vessels, were operating in the same area over extended periods of time (20 hours) in close proximity.
- Exercises took place in an area surrounded by landmasses, or in an embayment. Operations involving multiple ships employing mid-frequency active sonar near land may produce sound directed towards a channel or embayment that may cut off the lines of egress for marine mammals (Freitas, 2004).

H.7 OTHER GLOBAL STRANDING DISCUSSIONS

In the following sections, stranding events that have been putatively linked to DON activity in popular press are presented. As detailed in the individual case study conclusions, the DON believes that there is enough to evidence available to refute allegations of impacts from mid-frequency sonar.

Stranding Events Case Studies

2003 Washington State Harbor Porpoise Strandings (May 2 – June 2, 2003)

Description: At 10:40 a.m. on May 5, 2003, the USS Shoup began the use of mid-frequency tactical active sonar as part of a naval exercise. At 2:20 p.m., the USS Shoup entered the Haro Strait and terminated active sonar use at 2:38 p.m., thus limiting active sonar use within the strait to less than 20 minutes. Between May 2 and June 2, 2003, approximately 16 strandings involving 15 harbor porpoises (*Phocoena phocoena*) and one Dall's porpoise (*Phocoenoides dalli*) were reported to the Northwest Marine Mammal Stranding Network. A comprehensive review of all strandings and the events involving USS Shoup on May 5, 2003, were presented in DON (2004). Given that the USS Shoup was known to have operated sonar in the strait on May 5, and that supposed behavioral reactions of killer whales (*Orcinus orca*) had been putatively linked to these sonar operations (NMFS Office of Protected Resources, 2005), NMFS undertook an analysis of whether sonar caused the strandings of the harbor porpoises.

Whole carcasses of ten of harbor porpoises and the head of an additional porpoise were collected for analysis. Necropsies were performed on ten of the harbor porpoises and six whole carcasses and two heads were selected for CT imaging. Gross examination, histopathology, age determination, blubber analysis, and various other analyses were conducted on each of the carcasses (Norman et al., 2004).

Findings: Post-mortem findings and analysis details are found in Norman et al. (2004). All of the carcasses suffered from some degree of freeze-thaw artifact that hampered gross and histological evaluations. At the time of necropsy, three of the porpoises were moderately fresh, whereas the remainder of the carcasses was considered to have moderate to advanced decomposition. None of the 11 harbor porpoises demonstrated signs of acoustic trauma. In contrast, a putative cause of death was determined for five of the porpoises; two animals had blunt trauma injuries and three animals had indication of disease processes (fibrous peritonitis, salmonellosis, and necrotizing pneumonia). A cause of death could not be determined in the remaining animals, which is consistent with expected percentage of marine mammal necropsies conducted within the northwest region.

Conclusions: NMFS concluded from a retrospective analysis of stranding events that the number of harbor porpoise stranding events in the approximate month surrounding the USS Shoup use of sonar was higher than expected based on annual strandings of harbor porpoises (Norman et al., 2004). It is important to note that the number of strandings in the May-June timeframe in 2003 was also higher for the outer coast, indicating a much wider phenemona than use of sonar by USS Shoup in Puget Sound for one day in May. The conclusion by NMFS that the number of strandings in 2003 was higher is also different from that of The Whale Museum, which has documented and responded to harbor porpoise strandings since 1980 (Osborne, 2003). According to The Whale Museum, the number of strandings as of May 15, 2003, was consistent with what was expected based on historical stranding records and was less than that occurring in certain years. For example, since 1992 the San Juan Stranding Network has documented an average of 5.8 porpoise strandings per year. In 1997, there were 12 strandings in the San Juan Islands with more than 30 strandings throughout the general Puget Sound area. Disregarding the discrepancy in the historical rate of porpoise strandings and its relation to the USS Shoup, NMFS acknowledged that the intense level of media attention focused on the strandings likely resulted in an increased reporting effort by the public over that which is normally observed (Norman et al., 2004). NMFS also noted in its report that the "sample size is too small and biased to infer a specific relationship with respect to sonar usage and subsequent strandings."

Seven of the porpoises collected and analyzed died prior to Shoup departing to sea on May 5, 2003. Of these seven, one, discovered on May 5, 2003, was in a state of moderate decomposition, indicating it died before May 5; the cause of death was determined to be due, most likely, to salmonella septicemia. Another porpoise, discovered at Port Angeles on May 6, 2003, was in a state of moderate decomposition, indicating that this porpoise also died prior to May 5. One stranded harbor porpoise discovered fresh on May 6 is the only animal that could potentially be linked in time to the USS Shoup's May 5 active sonar use. Necropsy results for this porpoise found no evidence of acoustic trauma. The remaining eight strandings were discovered one to three weeks after the USS Shoup's May 5 transit of the Haro Strait, making it difficult to causally link the sonar activities of the USS Shoup to the timing of the strandings. Two of the eight porpoises died from blunt trauma injury and a third suffered from parasitic infestation, which possibly contributed to its death (Norman et al., 2004). For the remaining five porpoises, NMFS was unable to identify the causes of death.

The speculative association of the harbor porpoise strandings to the use of sonar by the USS Shoup is inconsistent with prior stranding events linked to the use of mid-frequency sonar. Specifically, in prior events, the stranding of whales occurred over a short period of time (less than 36 hours), stranded individuals were spatially co-located, traumas in stranded animals were consistent between events, and active sonar was known or suspected to be in use. Although mid-frequency active sonar was used by the USS Shoup, the distribution of harbor porpoise strandings by location and with respect to time surrounding the event do not support the suggestion that mid-frequency active sonar was a cause of harbor porpoise strandings. Rather, a complete lack of evidence of any acoustic trauma within the harbor porpoises, and the identification of probable causes of stranding or death in several animals, further supports the conclusion that harbor porpoise strandings were unrelated to the sonar activities of the USS Shoup (DON, 2004).

2004 Hawai'i Melon-Headed Whale Mass Stranding (July 3-4, 2004)

<u>Description</u>: The majority of the following information is taken from the NMFS report on the stranding event (Southall et al., 2006). On the morning of July 3, 2004, 150 to 200 melon-headed whales (*Peponocephala electra*) entered Hanalei Bay, Kauai. Individuals attending a canoe blessing ceremony observed the animals entering the bay at approximately 7 a.m. The whales were reported entering the bay in a "wave as if they were chasing fish" (Braun 2005). At 6:45 a.m. on July 3, 2004, approximately 46.3 km (25 NM) north of Hanalei Bay, active sonar was tested briefly prior to the start of an anti-submarine warfare exercise.

The whales stopped in the southwest portion of the bay, grouping tightly, and displayed spy-hopping and tail-slapping behavior. As people went into the water among the whales, the pod separated into as many as four groups, with individual animals moving among the clusters. This continued through most of the day, with the animals slowly moving south and then southeast within the bay. By about 3 p.m., police arrived and kept people from interacting with the animals. At 4:45 p.m. on July 3, 2004, the RIMPAC Battle Watch Captain received a call from a National Marine Fisheries representative in Honolulu, Hawaii, reporting the sighting of as many as 200 melon-headed whales in Hanalei Bay. At 4:47 p.m. the Battle Watch Captain directed all ships in the area to cease active sonar transmissions.

At 7:20 p.m. on July 3, 2004, the whales were observed in a tight single pod 68.6 m (75 yards) from the southeast side of the bay. The pod was circling in a group and displayed frequent tail slapping and whistle vocalizations and some spy hopping. No predators were observed in the bay and no animals were reported as having fresh injuries. The pod stayed in the bay through the night of July 3, 2004.

On the morning of July 4, 2004, the whales were observed to still be in the bay and collected in a tight group. A decision was made at that time to attempt to herd the animals out of the bay. A 213 to 244-m (700- to 800-ft) rope was constructed by weaving together beach morning glory vines. This vine rope was tied between two canoes and with the assistance of 30 to 40 kayaks, was used to herd the animals out of the bay. By approximately 11:30 a.m. on July 4, 2004, the pod was coaxed out of the bay.

A single neonate melon-headed whale was observed in the bay on the afternoon of July 4, after the whale pod had left the bay. The following morning on July 5, 2004, the neonate was found stranded on Lumahai Beach. It was pushed back into the water but was found stranded dead between 9 and 10 a.m. near the Hanalei pier. NMFS collected the carcass and had it shipped to California for necropsy, tissue collection, and diagnostic imaging.

Following the stranding event, NMFS undertook an investigation of possible causative factors of the stranding. This analysis included available information on environmental factors, biological factors, and an analysis of the potential for sonar involvement. The latter analysis included vessels that utilized mid-frequency active sonar on the afternoon and evening of July 2. These vessels were to the southeast of Kauai, on the opposite side of the island from Hanalei Bay.

Findings: NMFS concluded from the acoustic analysis that the melon-headed whales would have had to have been on the southeast side of Kauai on July 2 to have been exposed to sonar from naval vessels on that day (Southall et al., 2006). There was no indication whether the animals were in that region or whether they were elsewhere on July 2. NMFS concluded that the animals would have had to swim from 1.4 to 4.0 m/s (3 to 9 mi/hr) for 6.5 to 17.5 hours after sonar transmissions ceased to reach Hanalei Bay by 7 a.m. on July 3. Sound transmissions by ships to the north of Hanalei Bay on July 3 were produced as part of exercises between 6:45 a.m. and 4:47 p.m. Propagation analysis conducted by the 3rd Fleet estimated that the level of sound from these transmissions at the mouth of Hanalei Bay could have ranged from 138 to 149 dB re: 1 µPa.

NMFS was unable to determine any environmental factors (e.g., harmful algal blooms, weather conditions) that may have contributed to the stranding. However, additional analysis by Navy investigators found that a full moon occurred the evening before the stranding and was coupled with a squid run (Mobley et al., 2007). In addition, a group of 500 to 700 melon-headed whales were observed to come close to shore and interact with humans in Sasanhaya Bay, Rota, on the same morning as the whales entered Hanalei Bay (Jefferson et al., 2006). Previous records further indicated that, though the entrance of melon-headed whales into the shallows is rare, it is not unprecedented. A pod of melon-headed whales entered Hilo Bay in the 1870s in a manner similar to that which occurred at Hanalei Bay in 2004.

The necropsy of the melon-headed whale calf suggested that the animal died from a lack of nutrition, likely following separation from its mother. The calf was estimated to be approximately one week old. Although the calf appeared not to have eaten for some time, it was not possible to determine whether the calf had ever nursed after it was born. The calf showed no signs of blunt trauma or viral disease and had no indications of acoustic injury.

<u>Conclusions</u>: Although it is not impossible, it is unlikely that the sound level from the sonar caused the melon-headed whales to enter Hanalei Bay. This conclusion is based on a number of factors:

1. The speculation that the whales may have been exposed to sonar the day before and then fled to the Hanalei Bay is not supported by reasonable expectation of animal behavior and swim speeds. The flight response of the animals would have had to persist for many hours following the cessation of sonar transmissions. Such responses have not been observed in marine mammals and no documentation of such persistent flight response after the cessation of a frightening stimulus has been observed in other mammals. The swim speeds, though feasible for the species, are highly unlikely to be maintained for the durations proposed, particularly since the pod was a mixed group containing both adults and neonates. Whereas Southall et al. (2006) suggest that the animals would have had to swim from 1.4 to 4.0 m/s (3 to 9 mi/hr) for 6.5 to 17.5 hours, it is improbable that a neonate could achieve the same for a period of many hours.

2. The area between the islands of Oahu and Kauai and the Pacific Missile Range Facility (PMRF) training range have been used in RIMPAC exercises for more than 20 years, and are used year-round for ASW training using mid frequency active sonar. Melon-headed whales inhabiting the waters around Kauai are likely not naive to the sound of sonar and there has never been another stranding event associated in time with ASW training at Kauai or in the Hawaiian Islands. Similarly, the waters surrounding Hawaii contain an abundance of marine mammals, many of which would have been exposed to the same sonar operations that were speculated to have affected the melon-headed whales. No other strandings were reported coincident with the RIMPAC exercises. This leaves it uncertain as to why melon-headed whales, and no other species of marine mammal, would respond to the sonar exposure by stranding.

3. At the nominal swim speed for melon-headed whales, the whales had to be within 2.8 and 3.7 km (1.5 and 2 NM) of Hanalei Bay before sonar was activated on July 3. The whales were not in their open ocean habitat but had to be close to shore at 6:45 a.m. when the sonar was activated to have been observed inside Hanalei Bay from the beach by 7 a.m.

(Hanalei Bay is very large area). This observation suggests that other potential factors could be causative of the stranding event (see below).

4. The simultaneous movement of 500 to 700 melon-headed whales and Risso's dolphins into Sasanhaya Bay, Rota, in the Northern Marianas Islands on the same morning as the 2004 Hanalei stranding (Jefferson et al., 2006) suggests that there may be a common factor which prompted the melon-headed whales to approach the shoreline. A full moon occurred the evening before the stranding and a run of squid was reported concomitant with the lunar activity (Mobley et al., 2007). Thus, it is possible that the melon-headed whales were capitalizing on a lunar event that provided an opportunity for relatively easy prey capture. A report of a pod entering Hilo Bay in the 1870s indicates that on at least one other occasion, melon-headed whales entered a bay in a manner similar to the occurrence at Hanalei Bay in July 2004. Thus, although melon-headed whales entering shallow embayments may be an infrequent event, and every such event might be considered anomalous, there is precedent for the occurrence.

5. The received noise sound levels at the bay were estimated to range from roughly 95 to 149 dB re: 1 µPa. Received levels as a function of time of day have not been reported, so it is not possible to determine when the presumed highest levels would have occurred and for how long. However, received levels in the upper range would have been audible by human participants in the bay. The statement by one interviewee that he heard "pings" that lasted an hour and that they were loud enough to hurt his ears is unreliable. Received levels necessary to cause pain over the duration stated would have been observed by most individuals in the water with the animals. No other such reports were obtained from people interacting with the animals in the water.

Although NMFS concluded that sonar use was a "plausible, if not likely, contributing factor in what may have been a confluence of events (Southall et al., 2006)," this conclusion was based primarily on the basis that there was an absence of any other compelling explanation. The authors of the NMFS report on the incident were unaware, at the time of publication, of the simultaneous event in Rota. In light of the simultaneous Rota event, the Hanalei stranding does not appear as anomalous as initially presented and the speculation that sonar was a causative factor is weakened. The Hanalei Bay incident does not share the characteristics observed with other mass strandings of whales coincident with sonar activity (e.g., specific traumas, species composition, etc.). In addition, the inability to conclusively link or exclude the impact of other environmental factors makes a causal link between sonar and the melon-headed whale strandings highly speculative at best.

1980- 2004 Beaked Whale Strandings in Japan (Brownell et al. 2004)

Description: Brownell et al. (2004) compared the historical occurrence of beaked whale strandings in Japan (where there are U.S. naval bases) with strandings in New Zealand (which lacks a U.S. naval base) and concluded the higher number of strandings in Japan may be related to the presence of U.S. Navy vessels using mid-frequency sonar. While the dates for the strandings were well documented, the authors of the study did not attempt to correlate the dates of any Navy activities or exercises with the dates of the strandings.

To fully investigate the allegation made by Brownell et al. (2004), the Center for Naval Analysis (CNA) looked at the past U.S. Naval exercise schedules from 1980 to 2004 for the water around Japan in comparison to the dates for the strandings provided by Brownell et al. (2004). None of the strandings occurred during or within weeks after any DON exercises. While the CNA analysis began by investigating the probabilistic nature of any co-occurrences, the results were a 100 percent probability that the strandings and sonar use were not correlated by time. Given there was no instance of co-occurrence in over 20 years of stranding data, it can be reasonably postulated that sonar use in Japanese waters by DON vessels did not lead to any of the strandings documented by Brownell et al. (2004).

2004 Alaska Beaked Whale Strandings (June 17 to July 19, 2004)

Description: Between June 17 and July 19, 2004, five beaked whales were discovered at various locations along 2,575 km (1,389.4 NM) of the Alaskan coastline, and one was found floating (dead) at sea. Because the DON exercise Alaska Shield/Northern Edge 2004 occurred within the approximate timeframe of these strandings, it has been alleged that sonar may have been the probable cause of these strandings.

The Alaska Shield/Northern Edge 2004 exercise consisted of a vessel-tracking event followed by a vessel-boarding search-and-seizure event. There was no ASW component to the exercise, no use of mid-frequency sonar, and no use of explosives in the water. There were no events in the Alaska Shield/Northern Edge exercise that could have caused any of the strandings over this 33 day period.

2005 North Carolina Marine Mammal Mass Stranding Event (January 15-16, 2005)

Description: On January 15 and 16, 2005, 36 marine mammals consisting of 33 short-finned pilot whales, one minke whale, and two dwarf sperm whales stranded alive on the beaches of North Carolina (Hohn et al., 2006a). The animals were scattered across a 111-km (59.9-NM) area from Cape Hatteras northward. Because of the live stranding of multiple species, the event was classified as a UME (Unusual Mortality Event). It is the only stranding on record for the region in which multiple offshore species were observed to strand within a two- to three-day period.

The DON indicated that from January 12 to 14, some unit level training with mid-frequency active sonar was conducted by vessels that were 93 to 185 km (50.2 to 99.8 NM) from Oregon Inlet. An expeditionary strike group was also conducting exercises to the southeast, but the closest point of active sonar transmission to the inlet was 650 km (350.7 NM) away. The unit level operations were not unusual for the area or time of year and the vessels were not involved in antisubmarine warfare exercises. Marine mammal observers on board the vessels did not detect any marine mammals during the period of unit level training. No sonar transmissions were made on January 15-16.

The National Weather Service reported that a severe weather event moved through North Carolina on January 13 and 14 (Figure H-4). The event was caused by an intense cold front that moved into an unusually warm and moist air mass that had been persisting across the eastern United States for about a week. The weather caused flooding in the western part of the state, considerable wind damage in central regions of the state, and at least three tornadoes that were reported in the north central part of the state. Severe, sustained (one to four days) winter storms are common for this region.

Over a two-day period (January 16-17), two dwarf sperm whales, 27 pilot whales, and one minke whale were necropsied and tissue samples collected. Twenty-five of the stranded cetacean heads were examined; two pilot whale heads and the heads of the dwarf sperm whales were analyzed by CT.

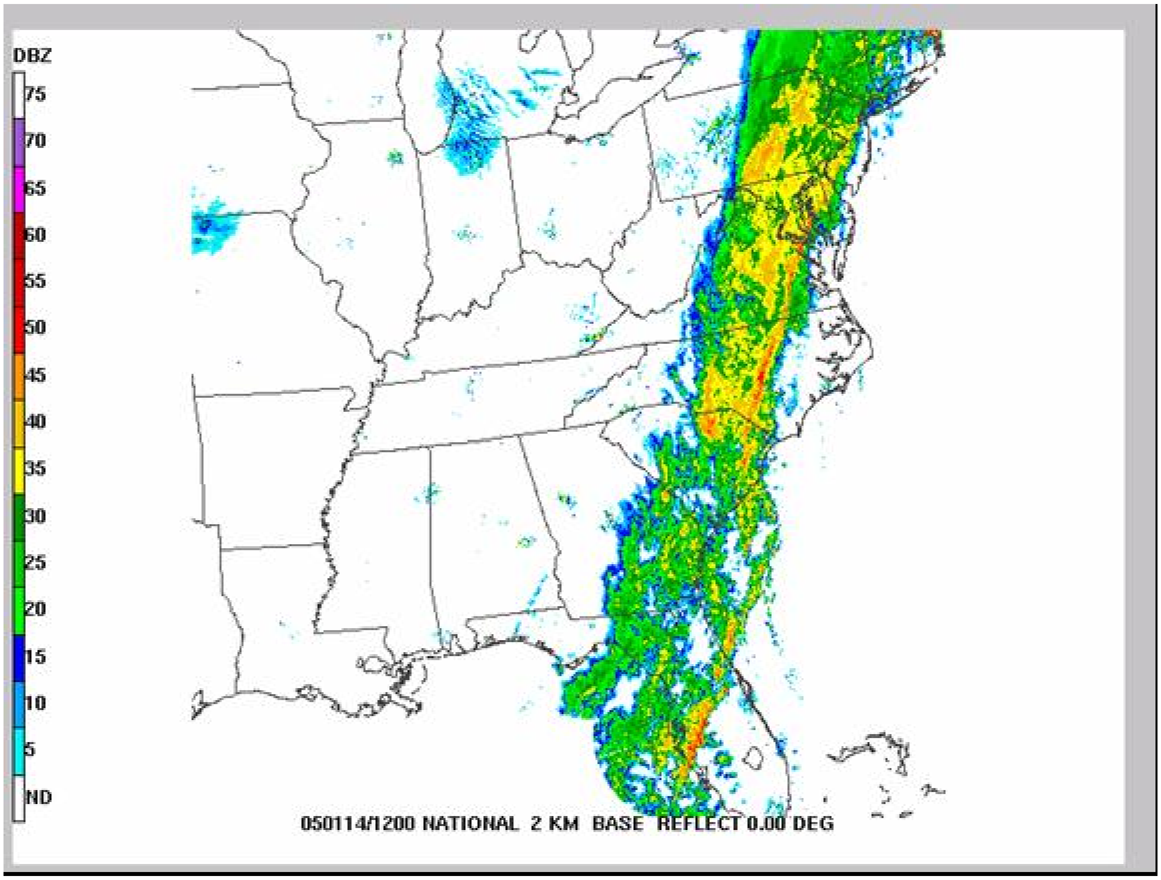


Figure H-4. Regional radar imagery for the East Coast (including North Carolina) on July 14. The time of the image is approximately 7 a.m.

Findings: The pilot whales and dwarf sperm whale were not emaciated, but the minke whale, which was believed to be a dependent calf, was emaciated. Many of the animals were on the beach for an extended period of time prior to necropsy and sampling, and many of the biochemical abnormalities noted in the animals were suspected of being related to the stranding and prolonged time on land. Lesions were observed in all of the organs, but there was no consistency across species. Musculoskeletal disease was observed in two pilot whales and cardiovascular disease was observed in one dwarf sperm whale and one pilot whale. Parasites were a common finding in the pilot whales and dwarf sperm whales but were considered consistent with the expected parasite load for wild odontocetes. None of the animals exhibited traumas similar to those observed in prior stranding events associated with mid-frequency sonar activity. Specifically, there was an absence of auditory system trauma and no evidence of distributed and widespread bubble lesions or fat emboli, as was previously observed (Fernández et al., 2005).

Sonar transmissions prior to the strandings were limited in nature and did not share the concentration identified in previous events associated with mid-frequency active sonar use (Evans and England, 2001). The operational/environmental conditions were also dissimilar (e.g., no constrictive channel and a limited number of ships and sonar transmissions). NMFS noted that environmental conditions were favorable for a shift from up-welling to down-welling conditions, which could have contributed to the event. However, other severe storm conditions existed in the days surrounding the strandings and the impact of these weather conditions on at-sea conditions is unknown. No harmful algal blooms were noted along the coastline.

Conclusions: All of the species involved in this stranding event are known to strand in this region. Although the cause of the stranding could not be determined, several whales had preexisting conditions that could have contributed to the stranding. Cause of death for many of the whales was likely due to the physiological stresses associated with being stranded. A consistent suite of injuries across species, which was consistent with prior strandings where sonar exposure is expected to be a causative mechanism, was not observed.

NMFS was unable to determine any causative role that sonar may have played in the stranding event. The acoustic modeling performed, as in the Hanalei Bay incident, was hampered by uncertainty regarding the location of the animals at the time of sonar transmissions. However, as in the Hanalei Bay incident, the response of the animals following the cessation of transmissions would imply a flight response that persisted for many hours after the sound source was no longer operational. In contrast, the presence of a severe weather event passing through North Carolina during January 13 and 14 is a possible contributing factor to the North Carolina UME of January 15.

H.8 STRANDING SECTION CONCLUSIONS

Marine mammal strandings have been a historic and ongoing occurrence attributed to a variety of causes. Over the last fifty years, increased awareness and reporting has lead to more information about species effected and raised concerns about anthropogenic sources of stranding. While there has been some marine mammal mortalities potentially associated with mid-frequency sonar effects to a small number of species (primarily limited numbers of certain species of beaked whales), the significance and actual causative reason for any impacts is still subject to continued investigation. ICES (2005a) noted, that taken in context of marine mammal populations in general, sonar is not a major threat, nor a significant contributor to the overall ocean noise budget. However, continued research based on sound scientific principles is needed in order to avoid speculation as to stranding causes, and to further our understanding of potential effects or lack of effects from military mid-frequency sonar (Bradshaw et al., 2006; ICES 2005b; Barlow and Gisiner, 2006; Cox et al. 2006).

REFERENCES

Alexander, J. W., Solangi, M. A., and L. S. Riegel, 1989. "Vertebral osteomyelitis and suspected diskospondylitis in an Atlantic bottlenose dolphin (*Tursiops truncatus*)," Journal of Wildlife Diseases 25, 118-121.

Andrew, R.K., B. M., Howe, and J. A. Mercer, 2002. Ocean ambient sound: Comparing the 1960s with the 1990s for a receiver off the California coast. Journal of the Acoustic Society of America 3(2):65-70.

Arruda, J., A. Costidis, S. Cramer, D. R. Ketten, W. McLellan, E. W. Montie, M. Moore, and S. Rommel, 2007. "Odontocete Salvage, Necropsy, Ear Extraction, and Imaging Protocols," edited by N. M. Young (Ocean Research, Conservation and Solutions [ORCAS] and ONR), pp. 1-171.

Arveson, P.T. and D. J. Vendittis, 2006. Radiated noise characteristics of a modern cargo ship. Journal of the Acoustic Society of America 107(1):118-129.

Baird, R. W. and S. K. Hooker, 2000. "Ingestion of plastic and unusual prey by a juvenile harbour porpoise," Marine Pollution Bulletin 40, 719-720.

Baird, R.W., P. J. Stacey, D. A. Duffus, and K. M. Langelier, 2002. An evaluation of gray whale (*Eschrichtius robustus*) mortality incidental to fishing operations in British Columbia, Canada. Journal of Cetacean Research and Management 4(3):289-296.

Baird, R.W. and A. M. Gorgone, 2005. False killer whale dorsal fin disfigurements as a possible indicator of long-line fishery interactions in Hawaiian waters. Pacific Science 59(4):593-601.

Barlow, J. and R. Gisiner, 2006. Mitigating, monitoring and assessing the effects of anthropogenic sound on beaked whales. Journal of Cetacean Research and Management 7(3):239-249.

Bauer, G., Fuller, M., Perry, A., Dunn, J. R., and J. Zoeger, 1985. "Magnetoreception and biomineralization of magnetite in cetaceans," in Magnetite Biomineralization and Magnetoreception in Organisms: A New Biomagnetism edited by J. L. Kirschvink, D. S. Jones, and B. J. MacFadden (Plenum Press, New York), pp. 489-507.

Bergman, A., A. Bergstrand, and A. Bignert, 2001. "Renal lesions in Baltic grey seals (*Halichoerus grypus*) and ringed seals (*Phoca hispida botnica*)," Ambio 30, 397-409.

Borell, A., 1993. PCB and DDTs in blubber of cetaceans from the northeastern North Atlantic. Marine Pollution Bulletin 26:146-151.

Brabyn, M., and R. V. C. Frew, 1994. "New Zealand herd stranding sites do not relate to geomagnetic topography," Mar. Mammal Sci. 10, 195-207.

Brabyn, M. W., and I. G. McLean, 1992. "Oceanography and coastal topography of herd-stranding sites for whales in New Zealand," J. Mamm. 73, 469-476.

Bradshaw, C. J., K. Evans, and M. A. Hindell, 2006. "Mass cetacean strandings: A plea for empiricism," Conservation Biology 20, 584-586.

Braun, R. C., 2005. Personal communication via email between Dr. Robert Braun, National Marine Fisheries Service, Pacific Island Fisheries Science Center, Honolulu, Hawaii, and Mr. Conrad Erkelens, U.S. Pacific Fleet, Fleet Environmental Office, Pearl Harbor Hawaii, 1 September.

Brodie, E. C., F. M. D. Gulland, D. J. Greig, M. Hunter, J. Jaakola, J. S. Leger, T. A. Leighfield, and F. M. V. Dolah, 2006. "Domoic acid causes reproductive failure in California sea lions (*Zalophus californianus*)," Marine Mammal Science 22:700–707.

Brownell, R. L., Jr., T. Yamada, J. G. Mead, and A. van Helden, 2004. Mass strandings of Cuvier's beaked whales in Japan: U.S. naval acoustic link? Unpublished paper SC/56/E37 presented to IWC Scientific Committee, July 2004. 100 pp.

Campagna, C., V. Falabella, M. Lewis., 2007. Entanglement of southern elephant seals in squid fishing gear. Marine Mammal Science 23(2):414-418.

Carretta, J. V., J. Barlow, K. A. Forney, M. M. Muto, and J. Baker, 2001. U.S. Pacific marine mammal stock assessments: 2001. NOAA Technical Memorandum NOAA-TM-NMFS-SWFWC-317.

Carretta, T. Price, D. Petersen, and R. Read, 2004. Estimates of marine mammal, sea turtle, and seabird mortality in the California drift gillnet fishery for swordfish and thresher shark, 1996-2002. Marine Fisheries Review 66(2):21-30.

Carretta, J. V., K. A. Forney, M. M. Muto, J. Barlow, J. Baker, B. Hanson, and M. S. Lowry, 2007. "U.S. Pacific Marine Mammal Stock Assessments: 2006," (NOAA-TM-NMFS-SWFSC-398, National Marine Fisheries Service, Southwest Fisheries Science Center), p. 321.

Chambers, S., and R. N. James, 2005. "Sonar termination as a cause of mass cetacean strandings in Geographe Bay, south-western Australia," in Acoustics 2005, Acoustics in a Changing Environment (Busselton, Western Australia).

Clyne, H., 1999. Computer simulations of interactions between the North Atlantic right whale (*Eubalaena glacialis*) and shipping.

Cockcroft, V. G., Cliff, G., and Ross, G. J. B., 1989. "Shark predation on Indian Ocean bottlenose dolphins *Tursiops truncatus* off Natal, South Africa," South African Journal of Zoology 24, 305-310.

Conner, R. C., 2000. "Group living in whales and dolphins," in Cetacean Societies: Field Studies of Dolphins and Whales, edited by J. Mann, R. C. Conner, P. L. Tyack, and H. Whitehead (University of Chicago Press, Chicago), pp. 199-218.

Constantine, R., I. Visser, D. Buurman, R. Buurman, B. McFadden, 1998. "Killer whale (*Orcinus orca*) predation on dusky dolphins (*Lagenorhynchus obscurus*) in Kaikoura, New Zealand," Mar. Mammal Sci. 14, 324-330.

Cox, T. M., T. J. Ragen, A. J. Read, E. Vos, R. W. Baird, K. Balcomb, J. Barlow, J. Caldwell, T. Cranford, L. Crum, A. D'Amico, G. D'Spain, A. Fernández, J. Finneran, R. Gentry, W. Gerth, F. Gulland, J. Hildebrand, D. Houser, T. Hullar, P. D. Jepson, D. Ketten, C. D. Macleod, P. Miller, S. Moore, D. C. Mountain, D. Palka, P. Ponganis, S. Rommel, T. Rowles, B. Taylor, P. Tyack, D. Wartzok, R. Gisiner, J. Meads, and L. Benner, 2006. "Understanding the impacts of anthropogenic sound on beaked whales," J. Cetacean Res. Manage. 7, 177-187.

Crocker, D. E., D. P. Costa, B. J. Le Boeuf, P. M. Webb, and D. S. Houser, 2006. "Impacts of El Niño on the foraging behavior of female northern elephant seals," Mar. Ecol. Prog. Ser. 309.

Crum, L. A., M. R. Bailey, G. Jingfeng, P. R. Hilmo, S. G. Kargl, and T. J. Matula, 2005. "Monitoring bubble growth in supersaturated blood and tissue ex vivo and the relevance to marine mammal bioeffects," Acoustic Research Letters Online 6, 214-220.

Crum, L. A., and Y. Mao, 1996. “Acoustically enhanced bubble growth at low frequencies and its implications for human diver and marine mammal safety,” J. Acoust. Soc. Am. 99, 2898-2907.

Culik, B. M., 2002. “Review on Small Cetaceans: Distribution, Behaviour, Migration and Threats,” in United Nations Environment Programme, Convention on Migratory Species (Marine Mammal Action Plan/Regional Seas Reports and Studies No. 177), p. 343.

D’Amico, A., and W. Verboom, 1998. “Report of the Bioacoustics Panel, NATO/SACLANT,” pp. 2-1-2-60.

D’Spain, G.L., A. D’Amico, and D. M. Fromm., 2006. Properties of the underwater sound fields during some well documented beaked whale mass stranding events. Journal of Cetacean Research and Management 7(3):223-238.

Dailey, M., and W. A. Walker, 1978. “Parasitism as a factor (?) in single strandings of southern California cetaceans,” Journal of Parasitology 64, 593-596.

Dailey, M., M. Walsh, D. Odell, and T. Campbell, 1991. “Evidence of prenatal infection in the bottlenose dolphin (*Tursiops truncatus*) with the lungworm *Halocercus lagenorhynchi* (*Nematoda Pseudaliidae*),” Journal of Wildlife Diseases 27, 164-165.

Das, K., V. Debacker, S. Pillet, and J. M. Bouquegneau, 2003. “Heavy metals in marine mammals,” in Toxicology of Marine Mammals, edited by J. G. Vos, G. D. Bossart, M. Fournier, and T. J. O’Shea (Taylor & Francis, London), pp. 135-167.

De Guise, S., K. B. Beckmen, and S. D. Holladay, 2003. “Contaminants and marine mammal immunotoxicology and pathology,” in Toxicology of Marine Mammals, edited by J. G. Vos, G. D. Bossart, M. Fournier, and T. J. O’Shea (Taylor & Francis, London), pp. 38-54.

De Stephasis, R. and E. Urquiola, 2006. Collisions between ships and cetaceans in Spain. Report to the Scientific Committee, International Whaling Commission SC/58/BC5.

DeMaster, D., C. W. Fwler, S. L. Perry, and M. F. Richlen, 2001. “Predation and competition: The impact of fisheries on marine-mammal populations over the next one hundred years,” J. Mamm. 82, 641-651.

Dierauf, L. A., and F. M. D. Gulland, 2001. “Marine Mammal Unusual Mortality Events,” in Marine Mammal Medicine, edited by L. A. Dierauf, and F. M. D. Gulland (CRC Press, Boca Raton), pp. 69-81.

Domingo, M., J. Visa, M. Pumarola, A. J. Marco, L. Ferrer, R. Rabanal, and S. Kennedy, 1992. “Pathologic and immunocytochemical studies of morbillibirus infection in striped dolphins (*Stenella coeruleoalba*),” Veterinary Pathology 29, 1-10.

Dudok van Heel, W. H., 1966. “Navigation in cetacea,” in Whales, Dolphins, and Porpoises, edited by K. S. Norris (University of California Press, Berkeley), pp. 597-606.

Dunn, J. L., J. D. Buck, and T. R. Robeck, 2001. “Bacterial diseases of cetaceans and pinnipeds,” in Marine Mammal Medicine, edited by L. A. Dierauf, and F. M. D. Gulland (CRC Press, Boca Raton, FL), pp. 309-335.

Evans, D. L., 2002. “Report of the Workshop on Acoustic Resonance as a Source of Tissue Trauma in Cetaceans,” (Silver Spring, MD).

Evans, D. L., and G. R. England, 2001. "Joint Interim Report Bahamas Marine Mammal Stranding Event of 15-16 March 2000," (Department of Commerce), pp. 1-66.

Evans, K., and M. A. Hindell, 2004. The diet of sperm whales (*Physeter macrocephalus*) in southern Australian waters. ICES Journal of Marine Science, Vol 61, No 8, pp. 1313 - 1329.

Evans, K., R. Thresher, R. M. Warneke, C. J. A. Bradshaw, M. Pook, D. Thiele, and M. A. Hindell, 2005. "Periodic variability in cetacean strandings: links to large-scale climate events," Biology Letters 1, 147-150.

Fernández, A., J. Edwards, V. Martín, F. Rodríguez, A. Espinosa de los Monteros, P. Herráez, P. Castro, J. R. Jaber, and M. Arbelo, 2005. "Gas and fat embolic syndrome" involving a mass stranding of beaked whales exposed to anthropogenic sonar signals," Journal of Veterinary Pathology 42, 446-457.

Finneran, J. J., D. A. Carder, C. E. Schlundt, and S. H. Ridgway, 2005. "Temporary threshold shift (TTS) in bottlenose dolphins (*Tursiops truncatus*) exposed to mid-frequency tones," J. Acoust. Soc. Am. 118, 2696-2705.

Finneran, J. J., R. Dear, D. A. Carder, and S. H. Ridgway, 2003. "Auditory and behavioral responses of California sea lions (*Zalophus californianus*) to single underwater impulses from an arc-gap transducer," J. Acoust. Soc. Am. 114, 1667-1677.

Finneran, J. J., C. E. Schlundt, D. A. Carder, J. A. Clark, J. A. Young, J. B. Gaspin, and S. H. Ridgway, 2000. "Auditory and behavioral responses of bottlenose dolphins (*Tursiops truncatus*) and a beluga whale (*Delphinapterus leucas*) to impulsive sounds resembling distant signatures of underwater explosions," J. Acoust. Soc. Am. 108, 417-431.

Flewelling, L. J., J. P. Naar, J. P. Abbott, D. G. Baden, N. B. Barros, G. D. Bossart, M. Y. D. Bottein, D. G. Hammond, E. M. Haubold, C. A. Heil, M. S. Henry, H. M. Jacocks, T. A. Leighfield, R. H. Pierce, T. D. Pitchford, S. A. Rommel, P. S. Scott, K. A. Steidinger, E. W. Truby, F. M. V. Dolah, and J. H. Landsberg, 2005. "Brevetoxicosis: Red tides and marine mammal mortalities," Nature 435, 755-756.

Frantzis, A., 1998. "Does acoustic testing strand whales?" Nature, p. 29.

Freitas, L., 2004. "The stranding of three Cuvier's beaked whales *Ziphius cavirostris* in Madeira Archipelago - May 2000," in European Cetacean Society 17th Annual Conference (Las Palmas, Gran Canaria).

Frodello, J. P., and B. Marchand, 2001. "Cadmium, copper, lead, and zinc in five toothed whale species of the Mediterranean Sea," International Journal of Toxicology 20, 339-343.

Geraci, J. R., 1989. "Clinical investigation of the 1987-88 mass mortality of bottlenose dolphins along the U.S. central and south Atlantic coast," (Final report to the National Marine Fisheries Service, U. S. Navy, Office of Naval Research, and Marine Mammal Commission), pp. 1-63.

Geraci, J. R., and V. J. Lounsbury, 1993. Marine Mammals Ashore: A Field Guide for Strandings. Texas A&M University Sea Grant College Program, Galveston, TX.

Geraci, J. R., J. Harwood, and V. J. Lounsbury, 1999. "Marine mammal die-offs: Causes, investigations, and issues," in Conservation and management of marine mammals, edited by J. R. Twiss, and R. R. Reeves (Smithsonian Institution Press, Washington, DC), pp. 367-395.

Geraci, J. R., and V. J. Lounsbury, 2005. Marine Mammals Ashore: A Field Guide for Strandings (Second Edition) (National Aquarium in Baltimore, Baltimore, MD).

Geraci, J. R., and D. J. St.Aubin, 1987. "Effects of parasites on marine mammals," International Journal of Parasitology 17, 407-414.

Goodson, A.D., 1997. Developing deterrent devices designed to reduce the mortality of small cetaceans in commercial fishing nets. Marine and Freshwater Behaviour and Physiology 29:211-236.

Gorzelany, J. F., 1998. "Unusual deaths of two free-ranging Atlantic bottlenose dolphins (*Tursiops truncatus*) related to ingestion of recreational fishing gear," Mar. Mammal Sci. 14, 614-617.

Grachev, M. A., V. P. Kumarev, L. V. Mamaev, V. L. Zorin, L. V. Baranova, N. N. Denikina, S. I. Belkov, E. A. Petrov, and V. S. Kolesnik, 1989. "Distemper virus in Baikal seals," Nature 338, 209-210.

Greig, D. J., F. M. D. Gulland, C. Kreuder, 2005. "A decade of live California sea lion (*Zalophus californianus*) strandings along the central California coast: Causes and trends, 1991-2000," Aquat. Mammals 31, 11-22.

Guinet, C., L. G. Barrett-Lennard, B. Loyer, B, 2000. "Coordinated attack behavior and prey sharing by killer whales at Crozet Archipelago: strategies for feeding on negatively-buoyant prey," Mar. Mammal Sci. 16, 829-834.

Gulland, F. M. D., 2006. "Review of the Marine Mammal Unusual Mortality Event Response Program of the National Marine Fisheries Service," (Report to the Office of Protected Resources, NOAA/National Marine Fisheries Service, Silver Springs, MD), p. 32.

Gulland, F. M. D., and A. J. Hall, 2005. "The Role of Infectious Disease in Influencing Status and Trends," in Marine Mammal Research, edited by J. E. Reynolds, W. F. Perrin, R. R. Reeves, S. Montgomery, and T. J. Ragen (John Hopkins University Press, Baltimore), pp. 47-61.

Gulland, F.M.D. and A.J. Hall, 2007. Is marine mammal health deteriorating? Trends in global reporting of marine mammal disease. EcoHealth 4:135-150.

Gulland, F. M. D., M. Koski, L. J. Lowenstine, A. Colagross, L. Morgan, and T. Spraker, 1996. "Leptospirosis in California sea lions (*Zalophus califorianus*) stranded along the central California coast, 1981-1994," Journal of Wildife Diseases 32, 572-580.

Harwood, J., 2002. "Mass Die-offs," in Encyclopedia of Marine Mammals, edited by W. F. Perrin, B. Würsig, and J. G. M. Thewissen (Academic Press, San Diego), pp. 724-726.

Heithaus, M. R., 2001. "Shark attacks on bottlenose dolphins (*Tursiops aduncus*) in Shark Bay, Western Australia: Attack rate, bite scar frequencies and attack seasonality," Mar. Mammal Sci. 17, 526-539.

Heyning, J. E., and T. D. Lewis, 1990. Entanglements of baleen whales in fishing gear of southern California. Report International Whaling Commission 40:427-431.

Hickie, B. E., P. S. Ross, R. W. MacDonald, and J. K. B. Ford, 2007. Killer whales (*Orcinus orcas*) faced protracted health risks associated with lifetime exposure to PCBs. *Environmental Science and Technology*, 41:6613-6619.

Hiruki, L. M., M. K. Schwartz, and P. L. Boveng, 1999. "Hunting and social behaviour of leopard seals (*Hydrurga leptonyx*) at Seal Island, South Shetland Islands, Antarctica," Journal of Zoology 249, 97-109.

Hoelzel, A. R., 2003. Marine Mammal Biology: An Evolutionary Approach (Blackwell Publishing, Malden MA).

Hohn, A. A., D. S. Rotstein, C. A. Harms, and B. L. Southall, 2006a. "Multispecies mass stranding of pilot whales (*Globicephala macrorhynchus*), minke whale (Balaenoptera acutorostrata), and dwarf sperm whales (*Kogia sima*) in North Carolina on 15-16 January 2005," (Department of Commerce), p. 222.

Hohn, A. A., D. S. Rotstein, C. A. Harms, and B. L. Southall, 2006b. "Report on marine mammal unusual mortality event UMESE0501Sp: Multispecies mass stranding of pilot whales (*Globicephala macrorhynchus*), minke whale (*Balaenoptera acutorostrata*), and dwarf sperm whales (*Kogia sima*) in North Carolina on 15-16 January 2005," p. 222.

Houser, D. S., R. Howard, and S. Ridgway, 2001. "Can diving-induced tissue nitrogen supersaturation increase the chance of acoustically driven bubble growth in marine mammals?" J. theor. Biol. 213, 183-195.

International Council for the Exploration of the Sea (ICES), 2005a. Report of the Ad-hoc Group on the Impacts of Sonar on Cetaceans and Fish- 2nd edition. International Council for the Exploration of the Sea. ICES AGISC CM 2005/ACE:06. 25 pp.

International Council for the Exploration of the Sea (ICES), 2005b. Answer to DG Environment request on scientific information concerning impact of sonar activities on cetacean populations. International Council for the Exploration of the Sea. 5 pp.

Jasny, M., J. Reynolds, C. Horowitz, and A. Wetzler, 2005. "Sounding the Depths II: The rising toll of sonar, shipping, and industrial ocean noise on marine life. Natural Resources Defense Council. 84 pp.

Jefferson, T. A., D. Fertl, M. Michael, and T. D. Fagin, 2006. "An unusual encounter with a mixed school of melon-headed whales (*Peponocephala electra*) and rough-toothed dolphins (*Steno bredanesis*) at Rota, Northern Mariana Islands," Micronesica 38, 239-244.

Jefferson, T. A., P. J. Stacey, and R. W. Baird, 1991. A review of killer whale interactions with other marine mammals: Predation to co-existence. Mammal Review 21(4):151-180.

Jensen, A. S. and G. K. Silber, 2004. Large whale ship strike database. NOAA Technical Memorandum NMFS-OPR-25, January 2004.

Jepson, P. D., M. Arbelo, R. Deaville, I. A. R. Patterson, P. Castro, J. R. Baker, E. Degollada, H. M. Ross, P. Herráez, A. M. Pocknell, E. Rodriguez, F. E. Howie, A. Espinosa, R. J. Reid, J. R. Jaber, V. Martin, A. Cunningham, and A. Fernandez, 2003. "Gas-bubble lesions in stranded cetaceans," Nature 425, 575-576.

Jepson, P. D., P. M. Bennett, C. R. Allchin, R. J. Lae, T. Kuiken, J. R. Baker, E. Rogan, and J. K. Kirkwood, 1999. "Investigating potential associations between chronic exposure to polychlorinated biphenyls and infectious disease mortality in harbour porpoises from England and Wales," The Science of the Total Environment 243/244, 339-348.

Jepson, P. D., P. M. Bennett, R. Deaville, C. R. Allchin, J. R. Baker, and R. Law, 2005. "Relationships between polychlorinated biphenyls and health status in harbor porpoises (*Phocoena phocoena*) stranded in the United Kingdom," Environ. Toxicol. Chem. 24 238-248.

Johnson, J.H. and T. H. Woodley, 1998. A survey of acoustic harassment device (AHD) use in the Bay of Fundy, NB, Canada. Aquatic Mammals 24:51-61.

Kennedy, S., T. Kuiken, P. D. Jepson, R. Deaville, M. Forsyth, T. Barrett, M. W. G. van de Bildt, A. D. M. E. Osterhaus, T. Eybatov, C. Duck, A. Kydyrmanov, I. Mitrofanov, and S. Wilson, 2000. "Mass die-off of Caspian seals caused by canine distemper virus," Emerging Infectious Diseases 6, 637-639.Ketten, D., 2005. "Beaked whale necropsy findings for strandings in the Bahamas, Puerto Rico, and Madeira, 1999-2002," (Woods Hole Oceanographic Institution, Woods Hole, MA), p. 36.

Kirschvink, J. L., A. E. Dizon, and J. A. Westphal, 1986. "Evidence from strandings for geomagnetic sensitivity in cetaceans," J. Exp. Biol. 120, 1-24.

Klinowska, M., 1985. "Cetacean live stranding sites relate to geomagnetic topography," Aquat. Mammals 11, 27-32.

Klinowska, M., 1986. "Cetacean live stranding dates relate to geomagnetic disturbances," Aquat. Mammals 11, 109-119.

Knowlton, A. R., F. T. Korsmeyer, J. E. Kerwin, H. Y. Wu, and B. Hynes, 1995. The hydrodynamic effects of large vessels on right whales. Final Report to NOAA Fisheries. NMFS Contract No. 40EANFF400534. 81 p.

Knowlton, A. R., and S. D. Kraus, 2001. Mortality and serious injury of northern right whales (*Eubalaena glacialis*) in the western North Atlantic Ocean. Journal of Cetacean Research and Management (Special Issue) 2:193-208.

Kompanje, E. J. O., 1995. "On the occurrence of spondylosis deformans in white-beaked dolphins *Lagenorhynchus albirostris* (Gray, 1846) stranded on the Dutch coast," Zooligische Mededekingen Leiden 69, 231-250.

Krahn, M. M., M. B. Hanson, R. W. Baird, R. H. Boyer, D. G. Burrows, C. E. Emmons, J. K. B. Ford, L. L. Jones, D. P. Noren, P. S. Ross, G. S. Schorr, and T. K. Collier, 2007. Persistent organic pollutants and stable isotopes in biopsy samples (2004/2006) from Southern Resident killer whales. *Marine Pollution Bulletin* (2007), doi:10.1016/j.marpolbul.2007.08.015.

Lahvis, G. P., R. S. Wells, D. W. Kuehl, J. L. Stewart, H. L. Rhinehart, and C. S. Via, 1995. "Decreased lymphocyte responses in free-ranging bottlenose dolphins (*Tursiops truncatus*) are associated with increased concentrations of PCBs and DDT in peripheral blood," Environmental Health Perspectives 103, 67-72.

Laist, D. W., A. R. Knowlton, J. G. Mead, A. S. Collet, and M. Posesta, 2001. "Collisions between ships and whales," Mar. Mammal Sci. 17, 35-75.

Le Boeuf, B. J., and J. Reiter, 1991. "Biological effects associated with El Nino Southern Oscillation, 1982-83m on northern elephant seals breeding at Ano Nuevo, California," in Pinnipeds and El Nino: Responses to Environmental Stress, edited by F. Trillmich, and K. A. Ono (Springer-Verlag, Berlin), pp. 206-218.

Learmonth, J. A., C. D. Macleod, M. B. Santos, G. J. Pierce, H. Q. P. Crick, and R. A. Robinson, 2006. "Potential effects of climate change on marine mammals," Oceanography and Marine Biology: an Annual Review 44, 431-464.

Lipscomb, T. P., F. Y. Schulman, D. Moffett, and S. Kennedy, 1994. Morbilliviral disease in Atlantic bottlenose dolphins (*Tursiops truncatus*) from the 1987-88 epizootic. *Journal of Wildlife Diseases*, 30 (4), pp 567-571.

Madsen, P. T., M. A. Johnson, P. J. Miller, A. N. Soto, J. Lynch, and P. L. Tyack, 2006. Quantitative measures of air-gun pulses recorded on sperm whales (*Physeter macrocephalus*) using acoustic tags during controlled exposure experiments. Journal of the Acoustic Society of America 120(4):2366-2379.

Maldini, D., L. Mazzuca, and S. Atkinson, 2005. "Odontocete stranding patterns in the main Hawaiian islands (1937-2002): How do they compare with live animal surveys?" Pacific Science 59, 55-67.

Maybaum, H. L., 1989. Effects of a 3.3 kHz sonar system on humpback whales, *Megaptera noveangliaea,* in Hawaiian waters. Thesis, Masters of Science, University of Hawaii Manoa, August 1989. 112 p.

Maybaum, H. L., 1993. Responses of humpback whales to sonar sounds. Journal of the Acoustical Society of America 109:2455.

Mazzuca, L., S. Atkinson, B. Keating, and E. Nitta, 1999. "Cetacean mass strandings in the Hawaiian Archipelago, 1957-1998," Aquat. Mammals 25, 105-114.

McDonald, M. A., J. A. Hildebrand, and S. M. Wiggins, 2006. "Increases in deep ocean ambient noise in the northeast pacific west of San Nicolas Island, California" Journal of the Acoustical Society of America. 120(2):711-718.

Michel, J, R. Nairn, J. A. Johnson, and D. Hardin, 2001. Development and design of biological and physical monitoring protocols to evaluate the long-term impacts of offshore dredging operations on the marine environment. Final Report to the U.S. Department of Interior, Minerals Management Service, International Activities and Marine Minerals Divisions (INTERMAR), Herndon, CA. Contract No. 14-35-0001-31051. 116 p.

Mignucci-Giannoni, A. A., G. M. Toyos-Gonzalez, J. Perez-Padilla, M. A. Rodriguez-Lopez, and J. Overing, 2000. "Mass stranding of pygmy killer whales (*Feresa attenuata*) in the British Virgin Islands," J. Mar. Biol. Ass. U. K. 80, 759-760.

Marine Mammal Commission (MMC), 1999. Marine Mammals and Persistent Ocean Contaminants: Proceedings of the Marine Mammal Commission Workshop Keystone, Colorado, 12-15 October 1998.Mobley, J. R. Jr., S. W. Martin, D. Fromm, and P. E. Nachtigall, , 2007. Lunar influences as possible cause for simultaneous aggregations of melon-headed whales in Hanalei Bay, Kauai and Sasanhaya Bay, Rota. 17th Biennial Conference on the Biology of Marine Mammals. Cape Town, South Aftica. November 29 through December 3, 2007.

Moeller, R. B., 2003. "Pathology of marine mammals with special reference to infectious diseases," in Toxicology of Marine Mammals, edited by J. G. Vos, G. D. Bossart, M. Fournier, and T. J. O'Shea (Taylor & Francis, London), pp. 3-37.

Moore, M. J. and G. A. Early, 2004. Cumulative sperm whale bone damage and the bends. Science 306:2215.

Moore, M. J., B. Rubinstein, S. A. Norman, and T. Lipscomb, 2004. "A note on the most northerly record of Gervais' beaked whale from the western North Atlantic Ocean," J. Cetacean Res. Manage. 6, 279-281.

Moore, S. E., 2005. "Long-term Environmental Change and Marine Mammals," in Marine Mammal Research: Conservation Beyond Crisis, edited by J. E. Reynolds, W. F. Perrin, R. R. Reeves, S. Montgomery, and T. J. Ragen (John Hopkins University Press, Baltimore), pp. 137-147.

Morimitsu, T., T. Nagai,M. Ide, H. Kawano, A. Naichuu, M. Koono, and A. Ishii, 1987. "Mass stranding of *odontoceti* caused by parasitogenic eighth cranial neuropathy," Journal of Wildife Diseases 23, 586-590.

Morisaka, T. and R. C. Connor, 2007. Predation by killer whales (*Orcinus orca*) and the evolution of whistle loss and narrow-band high frequency clicks in odontocetes. Journal of Evolutionary Biology 20(4):1439-1458.

National Marine Fisheries Service (NMFS), 1997. Investigation of scientific information on the impacts of California sea lions and Pacific harbor seals on salmonids and on the coastal ecosystems of Washington, Oregon, and California. U.S. Department of Commerce, NOAA Technical Memorandum NMFS-NWFSC-28. 172 pp.

National Marine Fisheries Service (NMFS), 2004. "Interim Report on the Bottlenose Dolphin (*Tursiops truncatus*) Unusual Mortality Event Along the Panhandle of Florida, March-April 2004," (National Marine Fisheries Service), pp. 1-36.

National Marine Fisheries Service (Office of Protected Resources), 2005. "Assessment of Acoustic Exposures on Marine Mammals in Conjunction with USS Shoup Active Sonar Transmissions in the Eastern Strait of Juan de Fuca and Haro Strait, Washington, 5 May 2003."

National Marine Fisheries Service (NMFS), 2005a. Pygmy Sperm Whale (*Kogia breviceps*): Western North Atlantic Stock. Stock Assessment Report. December, 2005.

National Marine Fisheries Service (NMFS), 2005b. Long-Finned Pilot Whale (*Globicephala melas*): Western North Atlantic Stock. Stock Assessment Report. December, 2005.

National Marine Fisheries Service (NMFS), 2005c. Dwarf Sperm Whale (*Kogia sima*): Western North Atlantic Stock. Stock Assessment Report. December, 2005.

National Marine Fisheries Service (NMFS), 2005d. Harbor Porpoise (*Phocoena phocoena*): Gulf of Maine/Bay of Fundy Stock. Stock Assessment Report. December, 2005.

National Marine Fisheries Service (NMFS), 2007. "Draft Programmatic Environmental Impact Statement for the Marine Mammal Health and Stranding Response Program," (National Marine Fisheries Service, Office of Protected Resources), p. 1006.

National Marine Fisheries Service (NMFS), 2007a. FAQs about Marine Mammal Strandings. Retrieved from http://www.nmfs.noaa.gov/pr/health/faq.htm, 30 January 2007.

National Marine Fisheries Service (NMFS), 2007b. National Marine Fisheries Service, Office of Protected Resources. Hawaii Viewing Guidelines. Accessed 2/14/07. http://www.nmfs.noaa.gov/pr/education/hawaii/guidelines.htm

National Research Council (NRC), 1994. "Low-frequency Sound and Marine Mammals: Current Knowledge and Research Needs". (National Research Council of the National Academes, National Academes Press, Washington, DC).

National Research Council (NRC), 1996. "Natural Climate Variability on Decade-to-Century Time Scales". (National Research Council of the National Academes, National Academes Press, Washington, DC).

National Research Council (NRC), 2000. "Marine Mammals and Low-Frequency Sound-Progress Since 1994". (National Research Council of the National Academes, National Academes Press, Washington, DC).

National Research Council (NRC), 2003. "Ocean Noise and Marine Mammals". (National Research Council of the National Academes, National Academes Press, Washington, DC).

National Research Council (NRC), 2005. "Marine Mammal Populations and Ocean Noise". (National Research Council of the National Academes, National Academes Press, Washington, DC).

National Research Council (NRC), 2006. "Dynamic Changes in Marine Ecosystems: Fishing, Food Webs, and Future Options, Committee on Ecosystem Effects of Fishing: Phase II - Assessments of the Extent of Change and the Implications for Policy," (National Research Council, of the National Academes, National Academes Press, Washington, DC).

Nielsen, J. B., F. Nielsen, P. Jorgensen, and P. Grandjean, 2000. "Toxic metals and selenium in blood from pilot whales (*Globicephala melas*) and sperm whales (*Physeter catodon*)," Marine Pollution Bulletin 40, 348-351.

Nieri, M., E. Grau, B. Lamarch, and A. Aguilar, 1999. Mass mortality of Atlantic spotted dolphin (*Stenella frontalis*) caused by a fishing interaction in Mauritania. (Marine Mammal Science 15(3):847-854).

Norman, S. A., and J. G. Mead, 2001. "*Mesoplodon europaeus*," Mammalian Species 688, 1-5.

Norman, S. A., S. Raverty, B. McClellan, A. Pabst, D. Ketten, M. Fleetwood, J. K. Gaydos, B. Norberg, L. Barre, T. Cox, B. Hanson, and S. Jeffries, 2004. "Multidisciplinary investigation of stranded harbor porpoises (*Phocoena phocoena*) in Washington State with an assessment of acoustic trauma as a contributory factor (2 May – 2 June 2003)," (United States Department of Commerce), p. 120.

Nowacek, D., M. P. Johnson, and P. L. Tyack, 2004. North Atlantic right whales (*Eubalaena glacialis*) ignore ships by respond to alerting stimuli. Proceedings of the Royal Society of London, Series B. Biological Sciences 271:227-231.

Nowacek, D. P., L. H. Thorne, D. W. Johnston, and P. L. Tyack, 2007. Responses of cetaceans to anthropogenic noise. Mammal Review 37(2):81-115.

Odell, D. K., 1987. The mystery of marine mammal strandings. Cetus 7:2.

O'Hara, T. M. and C. Rice, 1996. Polychlorinated biphenyls. In: A. Fairbrother, L. Locke, and G Hoff (eds). Noninfectious diseases of wildlife, 2nd edition. Iowa State University Press, Ames, Iowa.

O'Hara, T. M., M. M. Krahn, D. Boyd, P. R. Becker, and L. M. Philo, 1999. Organochlorine contaminant levels in Eskimo harvested bowhead whales of arctic Alaska. Journal of Wildlife Diseases 35(4):741-752.

Oliveira de Meirelles, A. C., and H. M. D. R. Barros, 2007. Plastic debris ingested by a rough-toothed dolphin, *Steno bredanensis*, stranded alive in northeastern Brazil. *Biotemas*, 20(1):127-131. March 2007.

O'Shea, T. J., and R. L. Brownell, Jr., 1994. Organochlorine and metal contaminants in baleen whales: a review and evaluation of conservation implications. Science of the Total Environment 154:179-200.

Osborne, R., 2003. "Historical Information on Porpoise Strandings in San Juan County Relative to the May 5th Navy Sonar Incident," (The Whale Museum News and Events).

Pace, R. M, and G. K. Silber, 2005. Abstract- Simple analyses of ship and large whale collisions: Does speed kill? Sixteenth Biennial Conference on the Biology of Marine Mammals, San Diego, December 2005.

Palka, D. and M. Johnson (eds), 2007. Cooperative Research to Study Dive Patterns of Sperm Whales in the Atlantic Ocean. Minerals Management Service, New Orleans, LA. OCS Study MMS2007-033. 49 pp.

Parente, C. L., J. P. Araujo, and M. E. Araujo, 2007. Diversity of cetaceans as tool in monitoring environmental impacts of seismic surveys. Biota Neotrop 7(1):1-7.

Paterson, R. A., 1984. “Spondylitis deformans in a Bryde’s whale (*Balaenoptera edeni* Anderson) stranded on the southern coast of Queensland,” Journal of Wildife Diseases 20, 250-252.

Perrin, W. F., and J. R. Geraci, 2002. “Stranding,” in Encyclopedia of Marine Mammals, edited by W. F. Perrin, B. Wursig, and J. G. M. Thewissen (Academic Press, San Diego), pp. 1192-1197.

Piantadosi, C. A., and E. D. Thalmann, 2004. “Whales, sonar and decompression sickness,” Nature 15 April 1-2.

Pitman, R. L., L. T. Ballance, S. L. Mesnick, and S. J. Chivers, 2001. “Killer whale predation on sperm whales: Observations and implications,” Mar. Mammal Sci. 17, 494-507.

Podesta, M., A. D’Amico, G. Pavan, A. Drouga, A. Komnenou,and N. Portunato, 2006. A review of *Ziphius cavirostris* strandings in the Mediterranean Sea. Journal of Cetacean Research and Mangagement 7(3):251-261.

Polefka, S., 2004. Anthropogenic Noise and the Channel Islands National Marine Sanctuary. Report by Environmental Defense Center, Santa Barbara, CA. 51 pp.

Rankin, J. J., 1953. “First record of the rare beaked whale, *Mesoplodon europaeus*, *Gervais*, from the West Indies,” Nature 172, 873-874.

Read, A. J., P. Drinker, and S. Northridge, 2006. “Bycatch of marine mammals in U.S. and global fisheries,” Conservation Biology 20, 163-169.

Resnick, D., and G. Niwayama, 2002. “Ankylosing spondylitis,” in Diagnosis of bone and joint disorders, edited by D. Resnick (W.B. Saunders Co., Philadelphia), pp. 1023-1081.

Ross, D., 1976. Mechanics of underwater noise. Pergamon, New York. 375 pp.

Richardson, W. J., C. R. Greene Jr., C. I. Malme, and D. H. Thomson, 1995. Marine Mammals and Noise (Academic Press, New York).

Ridgway, S. H. and M. D. Dailey, 1972. “Cerebral and cerebellar involvement of trematode parasites in dolphins and their possible role in stranding,” J. Wildlife Dis. 8, 33-43.

Ridgway, S. H. and R. Howard, 1979. “Dolphin lung collapse and intramuscular circulation during free diving: evidence from nitrogen washout,” Science 206, 1182-1183.

Robinson, S., L. Wynen, and S. Goldsworthy, 1999. “Predation by a Hooker’s sea lion (*Phocarctos hookeri*) on a small population of fur seals (*Arctocephalus spp*.) at Macquarie Island,” Mar. Mammal Sci. 15, 888-893.

Ross, P. E., R. L. DeSwart, R. F. Addison, H. VanLoveren, J. G. Vos, and A. Osterhaus, 1996. “Contaminant-induced immunotoxicity in harbour seals: wildlife at risk?” Toxicology 112, 157-169.

Simmonds, M. P. and L. F. Lopez-Jurado, 1991. Whales and the military. Nature 351:448.

Secchi, E. R., and S. Zarzur, 1999. "Plastic debris ingested by a Blainville's beaked whale, *Mesoplodon densirostris*, washed ashore in Brazil," Aquat. Mammals 25, 21-24.

Selzer, L. A. and P. M. Payne, 1988. "The distribution of white-sided dolphins (*Lagenorhynchus acutus*) and common dolphins (*Delphinus delphis*) vs. environmental features of the continental shelf of the northeastern United States," Mar. Mammal Sci. 4, 141-153.

Sergeant, D. E., 1982. "Some biological correlates of environmental conditions around Newfoundland during 1970-1979: harp seals, blue whales and fulmar petrels," (North Atlantic Fisheries Organization. NAFO. Scientific Council Studies), pp. 107-110.

Simmonds, M. P. and J. D. Hutchinson, 1996. "The Conservation of Whales and Dolphins: Science and Practice". John Wiley & Sons, Chichester, UK.

Simmonds, M. P. and L. F. Lopez-Jurado, 1991. "Whales and the military," Nature 351, 448.

Simmonds, M. P. and S. J. Mayer, 1997. "An evaluation of environmental and other factors in some recent marine mammal mortalities in Europe: implications for conservation and management," Environmental Review 5, 89-98.

Smithsonian Institution, 2000. Cetacean Distributional Database. Marine Mammal Program, Smithsonian Institution, Washington, DC.

Soto, N. A., M. Johnson, P. T. Madsen, P. L. Tyack, A. Bocconcelli, J. F. Borsani, 2006. Does intense ship noise disrupt foraging in deep-diving Cuvier's beaked whales (*Ziphius cavirostris*). Marine Mammal Science 22(3): 690-699.

Southall, B. L., R. Braun, F. M. D. Gulland, A. D. Heard, R. W. Baird, S. M. Wilkin, and T. K. Rowles, 2006. "Hawaiian melon-headed whale (*Peponocephala electra*) mass stranding event of July 3-4, 2004," 73 pp.

Stone, C. J. and M. J. Tasker, 2006. The effects of seismic airguns on cetaceans in U.K. waters. Journal of Cetacean Research and Management 8(3):255-263.

Struntz, W. D. J., J. R. Kucklick, M. M. Schantz, P. R. Becker, W. E. McFee, and M. K. Stolen, 2004. "Persistent organic pollutants in rough-toothed dolphins (*Steno bredanensis*) sampled during an unusual mass stranding event," Marine Pollution Bulletin 48, 164-192.Sweeny, M. M., J. M. Price, G. S. Jones, T. W. French, G. A. Early, and M. J. Moore, 2005. "Spondylitic changes in long-finned pilot whales (*Globicephala melas*) stranded on Cape Cod, Massachusetts, USA, between 1982 and 2000," J. Wildlife Dis. 41, 717-727.

Tarpley, R. J. and S. Marwitz, 1993. "Plastic debris ingestion by cetaceans along the Texas coast: two case reports," Aquat. Mammals 19, 93-98.

Trites, A. W., V. Christensen, and D. Pauly, 1997. "Competition between fisheries and marine mammals for prey and primary production in the Pacific Ocean," Journal of Northwest Atlantic Fishery Science 22, 173-187.

Urick, R. J., 1983. Principles of Underwater Sound for Engineers, McGraw-Hill, NY.

U.S. Department of Navy, 2001. Final Overseas Environmental Impact Statement and Environmental Impact Statement for Surveillance Towed Array Sensor System Low Frequency Active (SURTASS LFA) Sonar- Volume 1.

U.S. Department of Navy, 2004. Report on the Results of the Inquiry into Allegations of Marine Mammal Impacts Surrounding the Use of Active Sonar by USS Shoup (DDG 86) in the Haro Strait on or about 5 May 2003. February 2004.

Van Dolah, F. M., 2005. "Effects of Harmful Algal Blooms," in Marine Mammal Research, edited by J. E. Reynolds, W. F. Perrin, R. R. Reeves, S. Montgomery, and T. J. Ragen (John Hopkins University Press, Baltimore), pp. 85-99.

Van Dolah, F. M., G. J. Doucette, F. M. D. Gulland, T. L. Rowles, and G. Bossart, 2003. "Impacts of algal toxins on marine mammals," in Toxicology of Marine Mammals, edited by J. G. Vos, G. D. Bossart, M. Fournier, and T. J. O'Shea (Taylor & Francis, London), pp. 247-269.

Vanderlaan, A. S. M. and C. T. Taggart, 2007. Vessel collisions with whales: the probability of lethal injury based on vessel speed. Marine Mammal Science 23(1):144-156.

Vidal, O. and J. P. Gallo-Reynoso, 1996. "Die-offs of marine mammals and sea birds in the Gulf of California, Mexico," Mar. Mammal Sci. 12, 627-635.

Visser, I. K. G., J. S. Teppema, and A. D. M. E. Ostrhaus, 1991. "Virus infections of seals and other pinnipeds," Reviews in Medical Microbiology 2, 105-114.

Walker, M. M., J. L. Kirschvink, G. Ahmed, and A. E. Dizon, 1992. "Evidence that fin whales respond to the geomagnetic field during migration," J. Exp. Biol. 171, 67-78.

Walker, R. J., E. O. Keith, A. E. Yankovsky, and D. K. Odell, 2005. "Environmental correlates of cetacean mass stranding sites in Florida," Mar. Mammal Sci. 21, 327-335.

Walsh, M. T., R. Y. Ewing, D. K. Odell, and G. D. Bossart, 2001. "Mass Strandings of Cetaceans," in Marine Mammal Medicine, edited by L. A. Dierauf, and F. M. D. Gulland (CRC Press, Boca Raton), pp. 83-96.

Wartzok, D. and D. Ketten, 1999. "Marine mammal sensory systems," in The Biology of Marine Mammals, edited by J. E. Reynolds, and S. A. Rommel (Smithsonian Institution Press, Washington, DC).

Weise, M. J., D. P. Costa, and R. M. Kudela, 2006. "Movement and diving behavior of male California sea lion (*Zalophus californianus*) during anomalous oceanographic conditions of 2005," Geophysical Research Letters 33, L22S10.

Whitaker, B. R., J. R. Geraci, and A. Stamper, 1994. "The near-fatal ingestion of plastic by a pygmy sperm whale, *Kogia* breviceps," in IAAAM Proceedings, edited by B. Fenwick (Vallejo, CA), p. 108.

Whitehead, H., 2003. Sperm whales. University of Chicago Press, Chicago, Illinois.

Wilkinson, D. M., 1991. "Report to the Assistant Administrator for Fisheries, in Program Review of the Marine Mammal Stranding Networks," (U.S. Department of Commerce, NOAA, National Marine Fisheries Service, Silver Springs, MD), pp. 1-171.

Wilson, J., L. Rotterman, and D. Epperson, 2006. Minerals Management Service Overview of Seismic Survey Mitigation and Monitoring on the U.S. Outer Continental Shelf. Presented to the Scientific Committee of the International Whaling Commission, SC/58/E8. 13 pp.

Wittnich, C., M. Belanger, N. Askin, K. Bandali, and W. J. Wallen, 2004. "Awash in a sea of heavy metals: mercury pollution and marine animals," (Oceanographic Environmental Research Society and Canadian Marine Animal Rescue Network), pp. 1-70.

Ylitalo, G. M., J. E. Stein, T. Hom, L. L. Johnson, K. L. Tilbury, A. J. Hall, T. Rowles, D. Greig, L. J. Lowenstine, and F. M. D. Gulland, 2005. "The role of organochlorines in cancer-associated mortality in California sea lions (*Zalophus californianus*)," Marine Pollution Bulletin 50, 30-39.

Zeeberg, J., A. Corten, and E. de Graaf, 2006. Bycatch and release of pelagic megafauna in industrial trawler fisheries off Northwest Africa.. Fisheries Research 78:186-195.

Zimmerman, S. T. 1991. A history of marine mammal stranding networks in Alaska, with notes on the distribution of the most commonly stranded cetacean species, 1975-1987 In: J.E. Reynolds, and D.K. Odell 9ed). Marine Mammal Strandings in the United States: Proceedings of the Second Marine Mammal Stranding Workshop. NOAA Technical Report NMFS 98.