REQUEST FOR

Letter of Authorization

FOR THE INCIDENTAL HARASSMENT OF MARINE MAMMALS RESULTING FROM

Navy Training Activities

IN THE

GULF of ALASKA

TEMPORARY MARITIME ACTIVITIES AREA

COMMANDER UNITED STATES PACIFIC FLEET

November 2009
Revised Submittal

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Request for Letter of Authorization for the Incidental Harassment of Marine Mammals Resulting from Navy Training Activities in the Gulf of Alaska Temporary Maritime Activities Area

Submitted to:

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ACRONYMS AND ABBREVIATIONS

2-D	Two-Dimensional
3-D	Three- Dimensional
AAW	Anti-Air Warfare
A-G	Air-to-Ground
AAMEX	Air-to-Air Missile Exercise
ACM	Air Combat Maneuvers
AEER	Advanced Extended Echo Ranging
AESA	Airborne Electronically Scanned Array
AFB	Air Force Base
ASUW	Anti-Surface Warfare
ASW	Anti-Submarine Warfare
ATA	Alaska Training Areas
ATCAA	Air Traffic Control Assigned Airspace
BDA	Battle Damage Assessment
BDU	Bomb Dummy Unit
BFM	Basic Fighter Maneuvering
BOMBEX	Bombing Exercise
°C	degrees Celsius
cal	Caliber
CASS/GRAB	Comprehensive Acoustic Simulation System/Gaussian Ray Bundle
CFR	Code of Federal Regulations
CG	Guided Missile Cruiser
CHAFFEX	Chaff Exercise
CITES	Convention on International Trade in Endangered Species
CIWS	Close-in Weapons System
cm	centimeter
cm/sec	centimeters per second
COMPACFLT	Commander, U.S. Pacific Fleet
COMPTUEX	Composite Training Unit Exercise
CSG	Carrier Strike Group
CSAR	Combat Search and Rescue
CV	Coefficient of Variation
CVN	Aircraft Carrier, Nuclear
dB	decibel
DDG	Guided Missile Destroyer
DICASS	Directional Command Activated Sonobuoy System
DLQ	Deck Landing Qualification
DoD	Department of Defense
DoN	Department of Navy
DPS	Distinct Population Segment
DSCA	Defense Support of Civilian Authorities
EA	Electronic Attack
EC	Electronic Combat
EER	Extended Echo Ranging
EEZ	Exclusive Economic Zone
EIS	Environmental Impact Statement
EIT	Echo Integration Trawl
EMATT	Expendable Mobile ASW Training Target
ENSO	El Niño Southern Oscillation
EO	Executive Order
ES	Electronic Support
ESA	Endangered Species Act
EW	Electronic Warfare
°F	degrees Fahrenheit
FFG	Guided Missile Frigate
ft	feet
FY	Fiscal Year
GOALS	Gulf of Alaska Line-Transect Survey
GOA	Gulf of Alaska
GUNEX	Gunnery Exercise
HFA	High-Frequency Active
Hz	Hertz
ICAP	Improved Capability
ICMP	Integrated Comprehensive Monitoring Program
IEER	Improved Extended Echo Ranging
in	inch
IOC	Initial Operational Capability
ISR	Intelligence, Surveillance, and Reconnaissance
IUCN	World Conservation Union
IWC	International Whaling Commission
JASA-O	Journal of the Acoustical Society of American Online
JTF	Joint Task Force
JTFEX	Joint Task Force Exercise
kg	kilogram
kHz	kilohertz
km	kilometer
km^2	square kilometer
km/h	kilometers per hour
kts	Knots
lb	pound
LATN	Low-Altitude Tactical Navigation
LCS	Littoral Combat Ship
LFA	Low-Frequency Active
LFS SRP	Low-Frequency Sound Scientific Research Program
LGTR	Laser Guided Training Round
LOA	Letter of Authorization
m	meter
m/sec	meter per second
m^3/sec	cubic meter per second
μPa^2-s	micropascal squared per second
MFA	Mid-Frequency Active
MAC	Multistatic Active Coherent
mg/m^3	milligram per cubic meter
mi	miles
MI	Maritime Interdiction
MIO	Maritime Interdiction Operations
MISSILEX	Missile Exercise
MIW	Mine Warfare
mm	millimeter
MMA	Multi-mission Maritime Aircraft
MMPA	Marine Mammals Protection Act
MOA	Military Operations Area
MPA	Maritime Patrol Aircraft
MRA	Marine Resource Assessment
ms	milliseconds
MSAT	Marine Species Awareness Training
MSE	Multiple Successive Explosions
MTR	Military Training Routes
N-UCAS	Navy Unmanned Combat Air System
NA	Not Applicable
NATO	North Atlantic Treaty Organization
NAVEDTRA	Naval Education and Training
NCA	National Command Authority
NDAA	National Defense Authorization Act

NDE	National Defense Exemption
NEPA	National Environmental Policy Act
nm	nautical mile
nm^2	square nautical mile
NMFS	National Marine Fisheries Service
NMFS-OPR	NMFS-Office of Protected Resources
NOAA	National Oceanic and Atmospheric Administration
NORTHCOM	U.S. Northern Command
NPC	North Pacific Current
NPSG	North Pacific Subarctic Gyre
NSW	Naval Special Warfare
OEIS	Overseas Environmental Impact Statement
OPAREA	Operating Area
PACFIRE	Pre-action Calibration Firing
PACOM	U.S. Pacific Command
PDO	Pacific Decadal Oscillation
PMAR	Primary Mission Area
PR	Personnel Recovery
psi	Pounds Per Square Inch
PTS	Permanent Threshold Shift
PUTR	Portable Undersea Tracking Range
R&D	Research and Development
RL	Received Level
SAM	Surface-to-Air Missile
SBUs	Special Boat Units
SEAL	Sea, Air, Land
SeaWiFS	Sea-viewing Wide Field of view Sensor
§	Section
SEAD	Suppression of Enemy Air Defenses
SEL	Sound Exposure Level
SLAM-ER	Standoff Land Attack Missile Expanded Response
SNS	Sympathetic Nervous System
SOF	Special Operations Forces
SPL	Sound Pressure Level
SSC	Sea Surface Control
SSGN	Guided Missile Submarine
SSN	Fast Attack Submarine
SST	Sea Surface Temperature
STW	Strike Warfare
SUA	Special Use Airspace
SURTASS	Surveillance Towed Array Sensor System
TALD	Tactical Air Launched Decoy
TDU	Target Drone Unit
TL	Transmission Loss
TM	Tympanic Membrane
TMAA	Temporary Maritime Activities Area
TRACKEX	Tracking Exercise
TS	Threshold Shift
TTS	Temporary Threshold Shift
UAS	Unmanned Aerial System
USC	United States Code
USCG	United States Coast Guard
USFF	United States Fleet Forces
USFWS	United States Fish and Wildlife Service
VBSS	Visit Board Search and Seizure
VFR	Visual Flight Rules
VLAD	Vertical Line Array Directional Frequency
VOI	Vessel of Interest
VTNF	Variable, Timed, Non-Fragmentation
W-	Warning Area
yds	yards

EXECUTIVE SUMMARY

With this submittal, the U.S. Navy (Navy) requests a 5-year Letter of Authorization (LOA) for the incidental harassment and mortality of marine mammals incidental to Navy training within the Gulf of Alaska (GOA), Temporary Maritime Activities Area (TMAA) for the period September 2010 through September 2015, as permitted by the Marine Mammal Protection Act (MMPA) of 1972, as amended in 1994 (16 United States Code [USC] Section [§] 1371[a][5]). This document has been prepared in accordance with the applicable regulations and the MMPA, as amended by the National Defense Authorization Act (NDAA) for Fiscal Year 2004 (Public Law 108-136).

The proposed action consists of Navy training activities that occur during the summer in one or two major exercises or focused activity periods. These exercises or activity periods would each last up to 21 days and consist of multiple component training activities as described in greater detail in the body of this document. Unlike Navy training activities in other areas, the TMAA is not a Range Complex and as such, there are no other or ongoing small scale Navy training training activities conducted outside these activity periods. Subsequently, during the other 46-49 weeks of the year, the Navy doesn’t operate within the TMAA or other areas of the GOA.

An analysis was conducted for Navy training activities modeling the potential interaction of sound fields resulting from active sonar and at-sea explosions with marine mammals in the TMAA. MMPA Level B harassment in the context of military readiness activities is defined by the NDAA for Fiscal Year 2004 (Public Law 108-136) as 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. This estimate of total predicted marine mammal sound exposures potentially constituting MMPA Level B harassment is presented without consideration of the Navy’s standard mitigation measures. In addition, the assessment of whether temporary physiological effects or behavioral responses may cause behavioral patterns to be abandoned or significantly altered is considered in the context of an analytical framework for active sonar. This framework acknowledges that only a subset of exposures are likely to result in MMPA Level B harassment, and that multiple exposures to the same individual marine mammal have a higher likelihood of disturbance than single exposures. All predicted acoustic exposures are presented in this analytical framework to support the National Marine Fisheries Service (NMFS) assessment of those exposures that may result in MMPA Level B harassment. As discussed in detail in Section 6, MMPA Level A harassments are not expected to occur.

The potential sonar exposures outlined in Chapter 6 represent the estimated annual maximum number of exposures to marine mammals that may result in incidental harassment of marine mammals during Navy training in the TMAA. Based on the regulatory framework established under the MMPA, the Navy has worked with NMFS to develop criteria and methodology for evaluating when sound exposure from mid-frequency active/high-frequency active (MFA/HFA) sonar activities and explosives might constitute incidental harassment. The MMPA defines two types of harassment, Level A (potential injury) and Level B (disturbance), evaluated here for MFA/HFA sonar exposure as follows:

- MMPA Level A harassment: Consistent with prior actions, permanent physiological effects are considered injury, and Sound Exposure Level (SEL) is appropriate for evaluating when a sound exposure may cause a permanent physiological effect to marine mammals. SEL exposures at or above the lowest threshold at which the onset of a permanent physiological effect may occur are used to define potential Level A harassment (permanent threshold shift [PTS] at 215 decibels referenced to 1 micropascal squared per second (dB re 1 μPa^2-s) [SEL]). SEL thresholds for temporary physiological effects in pinnipeds are species-specific and are presented in Table ES-1.

- MMPA Level B harassment:
  - Level B harassment from temporary threshold shift (TTS): Consistent with prior actions, temporary, recoverable physiological effects are considered to potentially result in disturbance of marine mammals. Exposures below 215 dB re 1 μPa^2-s (SEL) and at or above the lowest exposures at which temporary physiological effects may occur (TTS at 195 dB re 1 μPa^2-s) are used to define potential Level B harassment. SEL thresholds for temporary physiological effects in pinnipeds are species-specific and are presented in Table ES-1.
  - Level B harassment from non-TTS: In addition to considering temporary physiological effects that may cause disturbance, this action also considers the potential for behavioral and physiological responses (e.g., stress) to behaviorally disturb marine mammals. Based on NMFS rulemaking for the Hawaii Range Complex Environmental Impact Statement/Overseas Environmental Impact Statement (National Oceanic and Atmospheric Administration 2008c), a risk function based on a Sound Pressure Level (SPL) metric is used to determine when these responses might be considered MMPA Level B harassment from non-TTS.

Table ES-1. Summary of the Physiological Effects Thresholds for TTS and PTS for Cetaceans and Pinnipeds (Sonar Exposure)

Species	Criteria	Threshold (dB re 1μPa^2-s)	MMPA Harassment
Cetacean All species	TTS PTS	195 215	Level B Level A
Pinniped			
California Sea Lion	TTS PTS	206 226	Level B Level A
Northern Elephant Seal	TTS PTS	204 224	Level B Level A
Northern Fur Seal	TTS PTS	206 226	Level B Level A
Steller Sea Lion	TTS PTS	206 226	Level B Level A

Notes: dB re 1μPa^2-s = decibels referenced to 1 micropascal squared per second, MMPA = Marine Mammal Protection Act, PTS = Permanent Threshold Shift, TTS = Temporary Threshold Shift

Modeling of marine mammals impacts under the present methodology requires a known marine mammals density. For some species for which this information is lacking and/or for species for which a density can be derived but are few in number, modeling will not return an estimate of exposures greater than or equal to one. For these species rare in the TMAA, for each proposed 21-day exercise period, the number of behavioral harassments per rare species will be based on an assumption of having exposed the species average group size to one instance of behavioral harassment to account for all at-sea explosions and one instance average group size behavioral harassment to account for all acoustic sources (e.g., sonar, pingers, EMATT) for purposes of this analysis in the TMAA. This use of average group size was only used if there was no data available for modeling or if modeling resulted in zero exposures for the species.

The modeling analysis used to estimate the maximum number of marine mammals that could be exposed annually by Navy training using active sonar will overestimate the potential effects given there has been no attempt to quantify reductions in the estimate based on implementation of standard Navy mitigation measures. The modeling and accounting for rare species results in a total of 425,551 sonar and non-sonar acoustic source exposures that NMFS may consider behavioral reactions resulting in incidental Level B harassment under the MMPA for military readiness activities (Table ES-2). Within this total, accounting for rare species (n=8) and risk function modeling for active sonar use indicates 424,620 marine mammals could be exposed to an SPL that NMFS may consider Level B harassment. This total also includes 931 Level B exposures that exceed the regulatory threshold using an SEL metric indicative of TTS.

Acoustic exposure modeling indicates one exposure (a summation of partial exposures across all training events that rounds to one) for Dall's porpoise that exceeds the regulatory threshold for permanent threshold shift (Level A harassment); however, this one exposure is not likely to occur given the Navy's standard mitigation measures.

Table ES-2. MMPA Level B Harassment Exposures

Source	Criteria	Level B Exposures
Sonar & non-Sonar Acoustic Sources	Non-TTS (Risk Function)	424,620
	TTS	931
	Sonar and non-Sonar Exposures Sub-Total	425,551
At-Sea Explosives	Sub-TTS (Multiple Successive Explosions)	170
	TTS	70
	At-Sea Explosives Exposures Sub-Total	240
	Total Level B	425,791

Notes: MMPA = Marine Mammal Protection Act; TTS = Temporary Threshold Shift

For at-sea explosions, potential exposures to underwater impulsive noise or pressure from at-sea explosions outlined in Chapter 6 represent the maximum expected number of cetaceans and pinnipeds that could be affected by training activities associated with Gunnery Exercise (GUNEX) and Bombing Exercise (BOMBEX). Modeling for at-sea explosions was undertaken using the following criteria:

- MMPA Level A harassment: Physiological effects including 50 percent tympanic membrane rupture (at 205 dB re 1 μPa^2-s [SEL]), onset of slight lung injury (Goertner Modified Positive Impulse to 13 pounds per square inch [psi]-milliseconds [ms]) and onset of extensive lung injury (Goertner Modified Positive Impulse to 30.5 psi-ms).
- MMPA Level B harassment:
    - Level B harassment from sub-TTS: Potential behavioral harassment at 177 dB re 1 μPa^2-s (SEL) for Multiple Successive Explosions (MSE).
    - Level B harassment from TTS: Behavioral harassment resulting from TTS at 182 dB re 1 μPa^2-s (SEL) or at 23 psi peak pressure

For at-sea explosions associated with the proposed training activities and without taking Navy area clearance procedures into account, modeling and accounting for rare species indicates 240 marine mammals may be exposed to impulsive noise or pressure from at-sea explosions that could result in behavioral modification (MMPA Level B harassment). Within this total MMPA Level B harassment estimate, 170 exposures exceed the threshold for MSE (with 16 of these exposures accounting for rare species) and 70 exceed the threshold for TTS. Modeling, without consideration of area clearance procedures, indicates four marine mammals could be exposed to impulsive noise or pressure from at-sea explosions that exceed thresholds indicative of injury (MMPA Level A harassment) and one potential mortality (onset extensive lung injury). As with the acoustic impacts from sonar activities, the analysis estimates the maximum number of marine mammals that could be affected by Navy training. Given area clearance procedures in the vicinity of events involving at-sea explosions and implementation of standard mitigation measures, the Navy believes that, in actuality, there should be no MMPA Level A harassment or injuries or mortality resulting from these activities.

The total summation of marine mammals predicted to be exposed annually to sonar and at-sea explosions associated with two 21-day summer (April to October) exercises are given without taking into consideration the use of mitigation measures. The Navy routinely employs a number of mitigation measures, outlined in Chapter 11, which will substantially decrease the number of animals potentially exposed to at-sea explosions associated with training activities.

Although Navy Anti–Submarine Warfare (ASW) training has not been a part of past actions in the TMAA, there is a long history of intensive training activities having taken place in Southern California, Hawaii, the Pacific Northwest, and along the Atlantic coast in Navy concentration areas. Based on the long history of conducting those ongoing activities using the same basic equipment in the same general areas for decades without any indications of effects to marine mammals, the incidental harassment of marine mammals associated with the proposed Navy training in the TMAA is expected to have no more than negligible impacts on marine mammal species or stocks.

For marine mammal species listed and protected under the Endangered Species Act (ESA), modeling estimates that 23,881 ESA-listed marine mammals may be exposed to sound levels or pressure that, in the regulatory language of ESA, "may affect" these species (23,852 from exposure to sonar and 29 from exposure to at-sea explosions). The ongoing ESA Section 7 consultation will examine the anticipated responses and any associated fitness consequences for these ESA-listed species. However, given the results of the modeling and the implementation of mitigation measures, it is unlikely that activities would adversely affect these species. The interpretation of the modeling estimates that only Level B harassment is anticipated for all marine mammal species in the TMAA for the following reasons:

- The decades long history of the sonar training activities in Navy concentration areas in the Pacific without any indications of effect to marine mammal stock or species.
- The widely dispersed geography of the activities in the TMAA and evaluation of the potential for physiological and behavioral disturbance.
- The reduction of potential effects attributed to the Navy's standard mitigation measures.

In all cases, the conclusions are that the predicted Level B harassments potentially resulting from Navy training activities would have a negligible impact on marine mammal species or stocks present in the TMAA.

In addition to Level A and Level B harassment, the potential for mortality may also be considered in impacts to marine mammals for LOA authorizations. In a letter from NMFS to the Navy dated October 2006, NMFS indicated that Section 101(a)(5)(A) authorization is appropriate for MFA/HFA sonar activities because it allows NMFS to consider the potential for incidental mortality. NMFS' letter indicated, "Because mid-frequency sonar has been implicated in several marine mammal stranding events including some involving serious injury and mortality, and because there is no scientific consensus regarding the causal link between sonar and stranding events, NMFS cannot conclude with certainty the degree to which mitigation measures would eliminate or reduce the potential for serious injury or mortality."

There are five stranding events that have been temporally and spatially associated with naval operations utilizing MFA sonar (see Appendix A for details). These events over an 11-year period represent a small overall number of animals (40 animals). Four of the five events occurred during North Atlantic Treaty Organization (NATO) exercises or events where Navy presence was limited (these locations were Greece, Portugal, and Spain). One of the five events involved only Navy ships (in the Bahamas).

As a result of NMFS concern over possibility of beaked whale strandings associated with the use of MFA sonar, the Navy previously has requested authorization to take, by injury or mortality, marine mammals although those takes were not anticipated based on prior history or predicted by modeling (DoN 2008). Recent evidence from behavioral response studies using tagged beaked whales suggests beaked whales may be "particurarly sensitive to anthropogenic sounds, but there is no evidence that they have a special sensitivity to sonar compared with other signals" (Tyack 2009). The beaked whale's reactions to all introduced sound stimulus consisted of the animals stopping their clicking, producing fewer foraging buzzes than normal, and ending their dives in long and an unusually slow ascent moving away from the sound source (Tyack 2009). As previous authors (e.g., Cox et al. 2006, Southall et al. 2007) have stressed, context for exposure is important.

Evidence from the five beaked whale strandings suggest that the exposure of beaked whales to mid-frequency sonar in the presence of certain conditions (e.g., multiple units using tactical sonar, steep bathymetry, constricted channels, strong surface ducts, etc.) may result in strandings, potentially leading to mortality. Although these physical factors believed to contribute to the likelihood of beaked whale strandings are not present, in their aggregate, in the TMAA, scientific uncertainty exists regarding what other factors, or combination of factors, may contribute to beaked whale strandings. Some of these factors (the presence of beaked whales, multiple ships using active sonar, and a surface duct) may be present during ASW training in the TMAA on occasion (see Section 11.2.1).

Neither NMFS nor the Navy anticipates that marine mammal strandings or mortality will result from the use of MFA or HFA sonar during Navy exercises within the TMAA. Given, however, the potential for naturally occurring marine mammal strandings in GOA (e.g., natural mortality), it is possible that a stranding could co-occur with a Navy exercise even though the stranding is actually unrelated to and not caused by Navy activities. Accordingly, the Navy will include requests for take, by mortality, for three beaked whales in addition to 425,791 MMPA Level A and Level B harassments of marine mammals associated with annual Navy training activities in the TMAA.

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1 DESCRIPTION OF ACTIVITIES

This chapter describes the U.S. Navy (Navy) training activities conducted within the Gulf of Alaska (GOA) Temporary Maritime Activities Area (TMAA) with emphasis on those that could potentially result in Level A harassment or Level B harassment, under the Marine Mammal Protection Act (MMPA) of 1972, as amended in 1994 (16 United States Code [U.S.C.] Section [§] 1371[a][5]). The actions described with the potential to affect marine mammals that may be present within the TMAA are activities taking place during training events involving active tactical sonar and at-sea explosions.

The MMPA of 1972 authorizes the issuance of regulations and Letters of Authorization (LOAs) for the incidental taking of marine mammals by a specified activity for a period of not more than 5 years. The issuance occurs when the Secretary of Commerce, after notice has been published in the Federal Register and opportunity for comment has been provided, finds that such takes will have a negligible impact on the species and stocks of marine mammals and will not have an unmitigable adverse impact on their availability for subsistence uses. The National Marine Fisheries Service (NMFS) has promulgated implementing regulations under 50 Code of Federal Regulations (C.F.R.) § 216.101–106 that provide a mechanism for allowing the incidental, but not intentional, taking of marine mammals while engaged in a specified activity.

This document has been prepared in accordance with the applicable regulations and the MMPA, as amended by the National Defense Authorization Act (NDAA) for Fiscal Year 2004 (Public Law 108-136). The bases of this LOA request are (1) the analysis of spatial and temporal distributions of protected marine mammals in the TMAA (Figure 1-1), (2) a review of training activities that have the potential to affect marine mammals, and (3) a technical risk assessment to determine the likelihood of effects from use of active sonar and activities involving at-sea explosions during Navy training activities in the TMAA.

1.1 BACKGROUND

The Navy's mission is to organize, train, equip, and maintain combat-ready naval forces capable of winning wars, deterring aggression, and maintaining freedom of the seas. This mission is mandated by federal law (Title 10 U.S.C. § 5062), which ensures the readiness of the United States' naval forces.[1] The Navy executes this responsibility by establishing and executing training programs, including at-sea training and exercises, and ensuring naval forces have access to the ranges, operating areas, and airspace needed to develop and maintain skills for conducting naval activities. For purposes of this LOA request, exercises and training include only those activities conducted as part of a training exercise.

To meet the training requirements, the Navy is preparing an Environmental Impact Statement/Overseas Environmental Impact Statement (EIS/OEIS) to assess the potential environmental effects associated with ongoing and proposed naval activities in the Alaska Training Areas (ATA). The Navy is the lead agency for the GOA Navy Training Activities EIS/OEIS, and NMFS is a cooperating agency pursuant to Title 40 C.F.R. § 1501.6 and 1508.5.

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[1] Title 10, Section 5062 of the United States Code provides: "The Navy shall be organized, trained, and equipped primarily for prompt and sustained combat incident to operations at sea. It is responsible for the preparation of Naval forces necessary for the effective prosecution of war except as otherwise assigned and, in accordance with Integrated Joint Mobilization Plans, for the expansion of the peacetime components of the Navy to meet the needs of war."

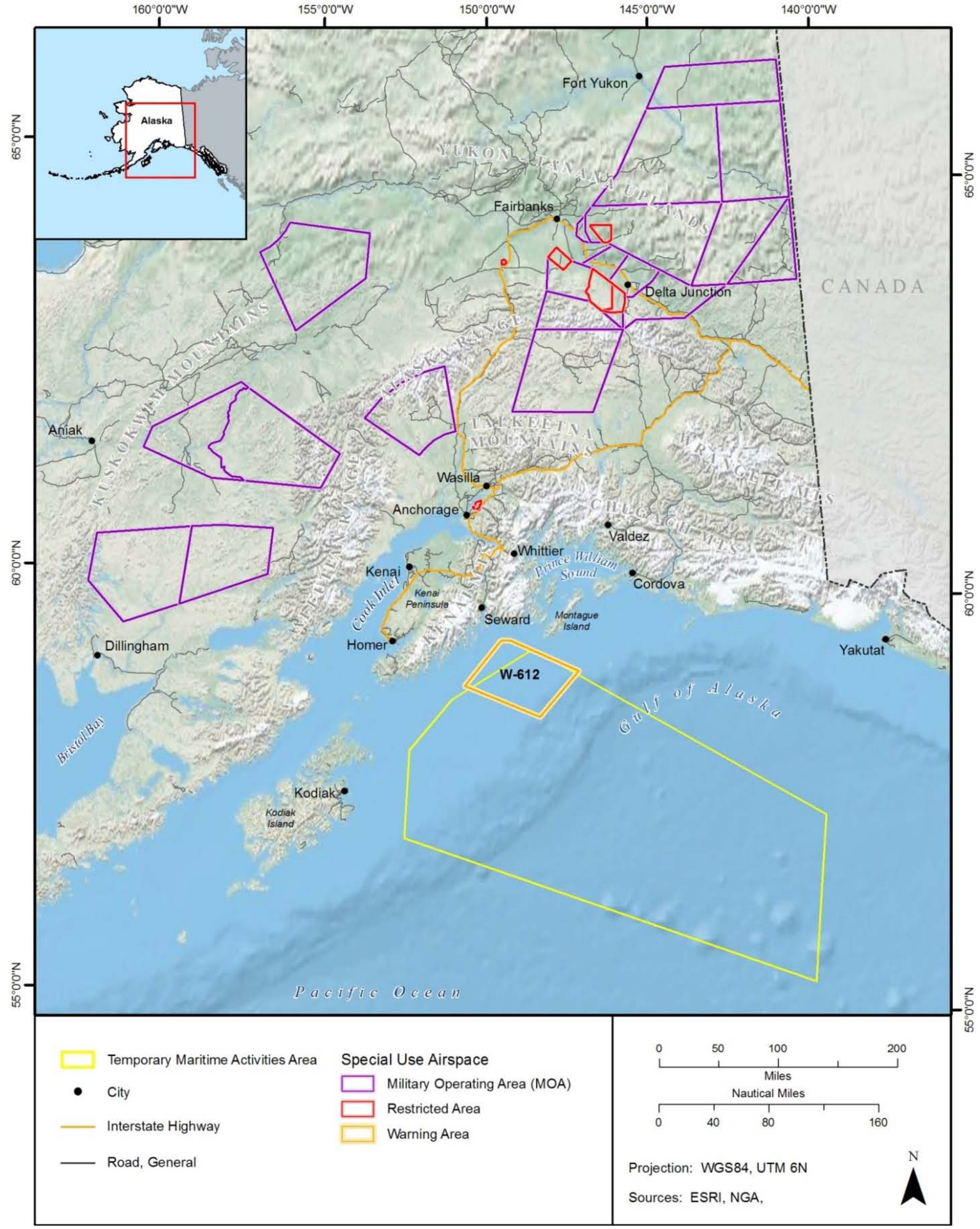

Figure 1-1. Alaska Training Areas

The areas making up the ATA, as depicted in Figure 1-1, consists of three components: 1) the TMAA; 2) U.S. Air Force (Air Force) over-land Special Use Airspace (SUA) and air routes over the GOA and State of Alaska, and 3) U.S. Army (Army) training lands.

The ATA has been used in the past for ongoing training associated with Navy joint training exercises since 1975. Previous exercises in the TMAA have occurred in the summer (May-June) timeframe due to the extreme cold weather and sea state conditions in the TMAA during the winter months.

Environmental Assessments were prepared for these exercises (since 1995) resulting in findings of no significant impact. There have been no identified impacts resulting from these exercises over this approximate 30-year period.

The purpose of the Proposed Action is to achieve and maintain fleet readiness using the ATA to support and conduct current, emerging, and future training activities. The Proposed Action does not include expansion of the geographic footprint of the TMAA for Navy training activities. In accordance with Section 7(c) of the Endangered Species Act (ESA) of 1973, as amended, the Navy is required to consult with NMFS and U.S. Fish and Wildlife Service (USFWS) for those actions it has determined may affect ESA-listed species or critical habitat. This LOA request provides the Navy's assessment of those activities in the TMAA which the Navy has determined could potentially result in Level A or Level B harassment under the MMPA.

1.2 PROPOSED ACTION

The TMAA has a unique combination of attributes that make it a strategically important training venue for the Navy. These attributes are described below.

1.2.1 General Location

The large contingent of Air Force aircraft based within a few hundred miles of the TMAA creates the possibility of rare joint training opportunities with Navy forces. The TMAA provides a maritime training venue that is located within flight range of Elmendorf Air Force Base (AFB), Eielson AFB, Fort Richardson, Fort Wainwright, Fort Greely, and their associated air and land training areas. Furthermore, numerous shipping lanes in the GOA and the abundance of commercial vessels on those shipping lanes provide critical training during homeland defense scenarios under real-world conditions.

1.2.2 Oceanographic Area and Conditions

The TMAA (see Figure 1-1) is composed of the 42,146 nm^2 (145,482 km^2) of surface and subsurface operating area and overlying airspace that includes the majority of Warning Area 612 (W-612) located over Blying Sound. The TMAA is roughly rectangular shaped and oriented from northwest to southeast, approximately 300 nautical miles (nm) (555.6 kilometers [km]) long by 150 nm (277.8 km) wide, situated south of Prince William Sound and east of Kodiak Island. The TMAA is bounded by the following coordinates: 57° 30'N, 141° 30'W to 59° 36'N, 148° 10'W to 58° 57'N, 150° 04'W to 58° 20'N, 151° 00'W to 57° 16'N, 151° 00'W to 55° 30'N, 142° 00'W. The majority of Navy training activities in the ATA occur in the TMAA (in both the ocean and the airspace above the TMAA).

Details regarding the physical environment present in the GOA and TMAA have been presented in the Navy's *Marine Resource Assessment for the Gulf of Alaska Operating Area* (MRA; Department of the Navy [DoN] 2006). A copy of this MRA has been included as part of the consultation package along with this LOA request. It should be noted that the boundaries of the "Gulf of Alaska OPAREA" presented in the MRA, although similar in shape to the current TMAA, are different in that the TMAA boundaries have been moved farther offshore along the northern and northwestern portion of the Proposed Action

Area. The new boundaries were drawn to avoid areas of critical habitat for Steller sea lions based on review of issues during scoping.

In general, water depths in the TMAA range from roughly 55 to 2,730 fathoms (330 to 16,380 feet [ft]; 100 to 5,000 meters [m]) deep. The North Pacific Current and the Alaska Coastal Current produce flows generally easterly through the TMAA (DoN 2006). The TMAA is an area of complex bathymetric and oceanographic conditions, including a continental shelf (approximately 60 miles [mi] [97 km] wide), sub-marine canyons, numerous seamounts, and fresh water infusions from multiple sources which reduce the salinity. All these conditions create a challenging environment in which to conduct Anti–Submarine Warfare (ASW) training activities.

Seamounts are isolated under sea mountains rising from 900 to 3,000 m (2,900 to 9,800 ft) above the surrounding bottom. Seamounts provide a unique habitat for both deep-sea and shallow water organisms due to the large ranges of depth, hard substrate, steep vertical gradients, cryptic topography, variable currents, clear oceanic waters, and geographic isolation that characterize seamount habitats. Seamount communities are extremely vulnerable to the impacts of fishing. (DoN 2006)

It has been suggested that a seamount could hold higher abundances of some marine mammals (e.g., sperm whales). While seamounts may act as feeding stations for some of these marine mammals, research of the Azores seamounts off Portugal failed to demonstrate a seamount association for bottlenose dolphins, spotted dolphins, sperm whales, and loggerhead turtles (Morato et al. 2008). Four Seamount Habitat Protection Areas are located in the TMAA (three partially): (1) Dall, (2) Kodiak, (3) Giacomini, and (4) Quinn (Figure 1-2). For similar conservation purposes, Slope Habitat Conservation Areas have been designated and two of these (Cable and Middleton West) are located within the TMAA.

The average Sea Surface Temperature (SST) for the GOA is reported to be approximately 9.6 degrees Celsius (°C; 49.3 degrees Fahrenheit [°F]) and has undergone a warming trend since 1957 (Aquarone and Adams 2008). Proposed activities associated with Navy training would take place in the summer months when water temperatures at the surface in the TMAA can be as high as 21°C (70°F; away from the coastal shelf and cold water coastal influx); however, temperature drops off rapidly with depth with the average temperature in the upper 100 m (328 ft) being approximately 11°C (52°F) and 3 to 4°C (37 to 39°F) at depth (300+ m [984+ ft]) year-round.

1.2.3 Training Airspace

Included in the airspace above the TMAA, is the SUA designated W-612. W-612 encompasses 2,256 nm^2 (8,766 km^2) of SUA centered south of Montague Island and southeast of Seward as depicted on Figure 1-1.

Associated with the TMAA, the ATA includes numerous Air Force airspace areas designated as Restricted Areas (RAs), Military Operations Areas (MOAs), or Visual Flight Rules (VFR) corridors. Other airspace for special use in Alaska consists of Military Training Routes (MTRs), Air Traffic Control Assigned Airspace (ATCAA), Air Refueling Anchors/Tracks, Low-Altitude Tactical Navigation (LATN) areas, Controlled Firing Areas, and Slow Speed Low-Altitude Training Routes. In total, these training areas comprise 46,585 nm^2 (159,782 km^2/61,692 mi^2) of SUA, 43,963 nm^2 (150,789 km^2/58,220 mi^2) of which is instrumented (ability to track, score and replay events), that overlays portions of the State of Alaska, generally to the west and north of Anchorage and to the east of Fairbanks. The Air Force's SUA in Alaska is among the largest components of SUA in the Air Force's range inventory, facilitating realistic training involving high speed military aircraft with the capability to traverse extensive airspace very quickly. A significant portion of naval air activity occurs in the Air Force's SUA.

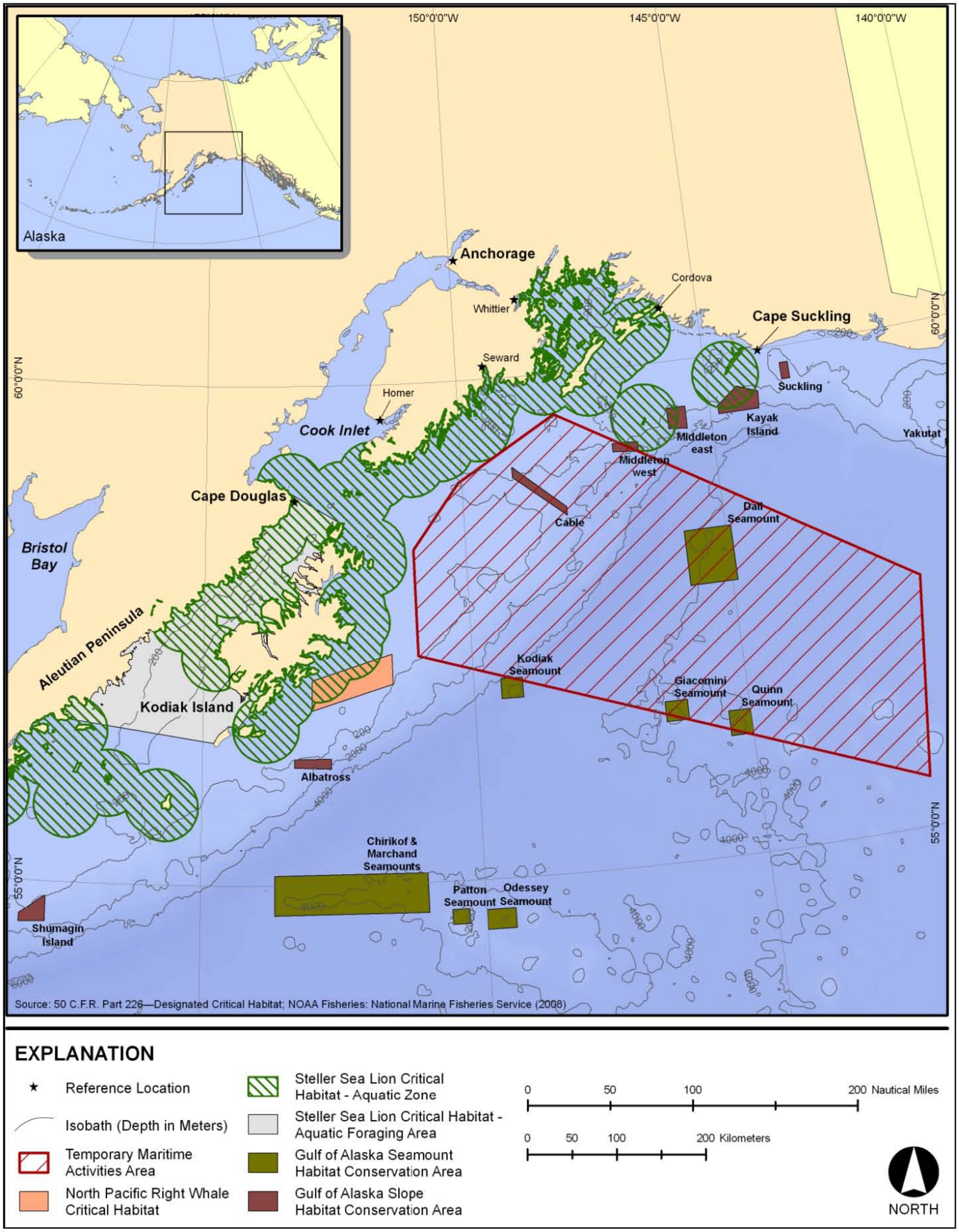

Figure 1-2. Critical Habitat and Habitat Conservation Areas in Vicinity of the Temporary Maritime Activities Area

Environmental impacts associated with training in and use of these airspaces and the associated land training areas was evaluated in the *Alaska Military Operations Areas Environmental Impact Statement* (Department of the Air Force, 1995) and the *Improvements to Military Training Routes in Alaska Environmental Assessment* (Department of the Air Force 2007).

1.2.4 Army Training Lands

The ATA includes numerous Army training lands generally located to the east of Fairbanks, below the Air Force's SUA. The Army's training lands in Alaska are among the largest of all training areas in the Army's inventory (roughly 1.3 times the size of the state of Delaware). These training lands provide an extensive suite of capabilities for tactical training, including live-fire training areas for small arms, maneuver areas, and other dedicated areas for the conduct of training. These training areas have extensive instrumentation, and provide opposing force simulation and targets for use in land and air live-fire training. Additionally, these training areas contain airfields, drop zones, landing zones, and other infrastructure for training and logistical support. Combined with the Air Force's SUA, these ground training areas provide Navy and Air Force aircraft with the capability to drop live and inert weapons on instrumented ranges in large, complex flying evolutions. Environmental impacts associated with Navy training activities in the airspace and associated training lands were evaluated in the *Alaska Army Lands Withdrawal Renewal Final Legislative EIS* (Department of the Army 1999) and the *Transformation of U.S. Army Alaska FEIS* (Department of the Army 2004).

1.2.5 Mission

The ATA is the principal training venue for the naval forces that participate in large-scale joint exercises in the Alaska area. Northern Edge[2] is a large-scale joint exercise that has been conducted annually, principally within the TMAA (see Figure 1-1 and Section 1.2 for description of the TMAA) for several years. The TMAA meets large-scale joint exercise training objectives to support naval and joint operational readiness by providing a "geographically realistic" training area for U.S. Pacific Command (PACOM), Joint Task Force Commander[3] scenario-based training, and supports the mission requirement of Alaskan Command (ALCOM)[4] to conduct joint training for Alaska-based forces. The strategic vision of the Commander, U.S. Pacific Fleet (CPF) and the Commander, United States Fleet Forces (USFF) for this training area is that it support naval operational readiness by providing a realistic, live-training environment for forces assigned to the Pacific Fleet and other users with the capability and capacity to support current, emerging, and future training requirements.

1.3 OVERVIEW PROPOSED OF THE TRAINING ACTIVITIES

Given the vital importance of the ATA to the readiness of naval forces and the unique training environment provided by the ATA, the Navy proposes to take actions for the purposes of:

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[2] Northern Edge is training exercise that exercises joint interoperability of service component forces by testing and evaluating contingency plans, policies, procedures, command structure, communications, logistics, and operations in a joint environment. The exercise also provides a venue for the development and implementation of joint experimentation in Alaska. Depending on the specific exercise objectives, Northern Edge may also incorporate joint task force training modules and transformation initiatives for air and space operations center employment, defensive counter air, counter surface/maritime interdiction, and personnel recovery.

[3] A Joint Task Force Commander and supporting staff is capable of planning and executing any contingency from relatively small-scale operations, such as noncombatant evacuations or maritime interdiction, to major theater conflict.

[4] The mission requirement of ALCOM is to: 1) integrate military activities within Alaska to maximize the readiness of theater forces, 2) expedite deployment of forces from and through Alaska in support of worldwide contingencies, and 3) serve as the Joint Task Force (JTF) headquarters for protection of critical infrastructure and coordination of Military Assistance to Civil Authorities.

- Supporting PACOM training requirements;
- Supporting Joint Task Force Commander training requirements;
- Achieving and maintaining Fleet readiness using the ATA to support and conduct current, emerging, and future training activities; and
- Expanding warfare missions supported by the ATA, consistent with requirements.

The Proposed Action is needed to continue providing a training environment with the capacity and capabilities to fully support required training tasks for operational units participating in joint exercises, such as the annual Northern Edge exercise. The Navy has developed alternatives criteria based on this statement of the purpose and need for the Proposed Action.

In this regard, the ATA furthers the Navy's execution of its roles and responsibilities under Title 10. To comply with its Title 10 mandate, the Navy needs to:

- Maintain current levels of military readiness by training in the ATA;
- Accommodate future increases in training activity tempo in the ATA;
- Support the acquisition and implementation into the Fleet of advanced military technology using the ATA to conduct training activities for new platforms and associated weapons systems (EA-18G Growler aircraft, Guided Missile Submarines [SSGN], P-8 Poseidon Multimission Maritime Aircraft [MMA], Guided Missile Destroyer [DDG] 1000 {Zumwalt Class destroyer}, and several types of Unmanned Aerial Systems [UASs]);
- Identify shortfalls in training, particularly training instrumentation and address through enhancements;
- Maintain the long-term viability of the ATA as a premiere Navy training area while protecting human health and the environment, and enhancing the quality, capabilities, and safety of the training area; and
- Be able to bring Army, Navy, Air Force, and Coast Guard assets together into one geographic area for joint training.

Table 1-1 summarizes the types of training activities in the TMAA. More detail on each of these activities is provided in Section 1.3.1.

Table 1-1. Summary of Proposed Training Activities in the TMAA

Warfare Area	Training Activity	NEPA		EO 12114
		Inland[2]	0-12 NM[3]	Beyond 12 NM
Anti-Air Warfare (AAW)	Aircraft Combat Maneuvers	X	X	X
	Air Defense Exercise		X	X
	Surface-to-Air Missile Exercise (MISSILEX)			X
	Surface-to-Air Gunnery Exercise (GUNEX)		X	X
	Air-to-Air MISSILEX		X	X
Anti-Submarine Warfare (ASW)[1]	Helicopter ASW Tracking Exercise (TRACKEX)			X
	Maritime Patrol Aircraft (MPA) ASW TRACKEX		X	X
	Extended Echo Ranging (EER) ASW Exercises			X
	Surface Ship ASW TRACKEX			X
	Submarine ASW TRACKEX			X
Anti-Surface Warfare (ASUW)	Visit Board Search and Seizure			X
	Air-to-Surface MISSILEX			X
	Air-to-Surface Bombing Exercise (BOMBEX)			X
	Air-to-Surface GUNEX			X
	Surface-to-Surface GUNEX			X
	Maritime Interdiction		X	X
	Sea Surface Control			X
	Sinking Exercise		X	X
Electronic Combat (EC)	EC Exercise	X	X	X
	Chaff Exercise	X	X	X
	Counter Targeting Exercise			X
Naval Special Warfare (NSW)	Insertion/Extraction	X		
Strike Warfare (STW)	Air-to-Ground BOMBEX	X	X	
	Personnel Recovery	X		X
N/A	Deck Landing Qualification (DLQs)			X

1 – ASW activities are not currently conducted in the TMAA. N/A – Not applicable.

2 - Navy inland activities are a part of the Proposed Action; however, those inland activities (including potential increases in training activities) are analyzed under existing USAF/Army National Environmental Policy Act (NEPA) documents.

3 – The only activities that occur within 0-12 nm are aircraft overflights above 15,000 feet.

The Navy routinely trains and operates in the ATA and the TMAA for national defense purposes. Training activities and exercises currently conducted in the ATA are briefly described below. Each military training activity described in this LOA request meets a requirement that can be traced ultimately to requirements from the National Command Authority[5]. Training activities in the ATA stem from large-scale joint exercises, such as Northern Edge, which may involve thousands of participants and span several days. These exercises include basic individual or unit level training events of relatively short duration involving few participants that occur simultaneously with the large-scale joint exercises. The main proposed action analyzed in this LOA request involves the portion of large-scale joint exercise training activities occurring in the TMAA involving a Carrier Strike Group (CSG) composed of one aircraft carrier (CVN), two DDGs, two Guided Missile Frigates (FFGs), one Guided Missile Cruiser (CG), and a submarine (or forces equivalent to a CSG). Training activities would occur during two exercises (lasting up to 21 days) in the summer timeframe (April through October).

Over the years, the tempo and types of activities have fluctuated within the ATA due to changing requirements, the introduction of new technologies, the dynamic nature of international events, advances in warfighting doctrine and procedures, and force structure changes. Such developments have influenced the frequency, duration, intensity, and location of required training. The factors influencing tempo and types of activities are fluid in nature, and will continue to cause fluctuations in training activities within the ATA. However, even with the fluidity of the training requirements, the “ceiling numbers” for the proposed action in this LOA will not be exceeded. Accordingly, training activity data used throughout this LOA request are a representative baseline for evaluating impacts that may result from the proposed training activities.

1.3.1 Description of Current Training Activities within the Alaska Training Areas

For purposes of analysis, training activity data used in this LOA request are organized by Navy Primary Mission Areas (PMARs). The Navy currently trains in five PMARs in the TMAA: Anti-Air Warfare (AAW), Anti-Surface Warfare (ASUW), Electronic Combat (EC), Naval Special Warfare (NSW), and Strike Warfare (STW). The Navy also conducts STW, EC, and NSW training in the Air Force SUA and Army training lands of the ATA. Although discussed in this document, these inland activities and their impacts are covered under separate NEPA documentation by the Air Force and Army (USAF 1995, USAF 1997, Army 1999, and Army 2004). Navy requirements will mandate ASW training activities take place in the TMAA using active sonar. Summary descriptions of current training activities conducted in the TMAA and other components of the ATA are provided in the following subsections.

1.3.1.1 AAW Training

In general, AAW is the PMAR that addresses combat activities by air and surface forces against hostile aircraft. Navy ships contain an array of modern anti-aircraft weapon systems, including naval guns linked to radar-directed fire-control systems, surface-to-air missile systems, and radar-controlled cannon for close-in point defense. Strike/fighter aircraft carry anti-aircraft weapons, including air-to-air missiles and aircraft cannons. AAW training encompasses events and exercises to train ship and aircraft crews in employment of these weapon systems against mock threat aircraft or targets. AAW training includes surface-to-air gunnery, surface-to-air and air-to-air missile exercises and aircraft force-on-force combat maneuvers. These training events are not likely to disturb a marine mammal or marine mammal stock resulting in Marine Mammal Protection Act (MMPA) Level B harassment as defined for military readiness activities.

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[5] National Command Authority (NCA) is a term used by the United States military and government to refer to the ultimate lawful source of military orders. The term refers collectively to the President of the United States (as commander-in-chief) and the United States Secretary of Defense.

Air Combat Maneuvers (ACM)

ACM includes Basic Flight Maneuvers (BFM) where aircraft engage in offensive and defensive maneuvering against each other. During an ACM engagement, no ordnance is fired. These maneuvers typically involve two aircraft; however, based upon the training requirement, ACM exercises may involve over a dozen aircraft. For the purposes of this document, aircraft activities will be described by the term "sortie." A sortie is defined as a single activity by one aircraft (i.e., one complete flight from takeoff to landing).

ACM activities within the ATA are conducted in the TMAA and the inland SUA of the Air Force. These events are not likely to disturb a marine mammal or marine mammal stock resulting in MMPA Level B harassment as defined for military readiness activities. These activities are primarily conducted by F/A-18 aircraft. However, for purposes of this study, ACM includes other aircraft activities conducted routinely in preparation for more advanced training flights such as ACM. These other activities include in-flight refueling, basic familiarization training, and formation flying. Additionally, Air Force F-15s, F-16s, and F/A-22s also conduct ACM in the TMAA. No ordnance is released during these exercises. When conducted in the inland SUA of the Air Force, these activities and their impacts are covered under other NEPA analyses (USAF 1995, USAF 1997, Army 1999, and Army 2004).

Air Defense Exercise

The Air Defense Exercise is an exercise to train surface and air assets in coordination and tactics for defense of the strike group or other Naval Forces from airborne threats. The activities occur within the TMAA; however, no ordnance is fired. This activity is not likely to disturb a marine mammal or marine mammal stock resulting in MMPA Level B harassment as defined for military readiness activities.

Surface-to-Air Missile Exercise

During a surface-to-air missile exercise, surface ships engage threat missiles and aircraft with missiles with the goal of disabling or destroying the threat. One live or 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 2 hours. The BQM-74E target drone, sometimes augmented with a Target Drone Unit (TDU), is used as 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. The Surface to Air Missile (SAM) launched can be a Rolling Airframe Missile if installed on an aircraft carrier; otherwise the SAM used is the NATO Sea Sparrow Missile or the Standard Missile. These activities occur within the TMAA and are not likely to disturb a marine mammal or marine mammal stock resulting in MMPA Level B harassment as defined for military readiness activities.

GUNEX Surface-to-Air

During a GUNEX S-A, a ship's gun crews engage threat aircraft or missile targets with their guns with the goal of disabling or destroying the threat. A typical scenario involving a DDG with 5-inch guns and/or a guided missile frigate (FFG) with 76 millimeter (mm) Main Battery Guns would have a threat aircraft or anti-ship missile being simulated by an aircraft towing a target (a cloth banner) toward the ship below 10,000 ft, at a speed between 250 and 500 knots (kts) (463 to 926 kilometers per hour [km/h]). Main battery guns are manned and 5-inch and/or 76mm rounds are fired at the threat with the goal of destroying the threat before it reaches the ship. This is a defensive exercise where about six rounds of 5-inch Variable Timed, Non-Fragmentation (VTNF) ammunition and/or 12 rounds of 76-mm per gun mount are fired at a target towed by a commercial air services Lear jet. The ship(s) maneuver but typically operate at 10 to 12 kts (18 to 22 km/h) or less during the exercise. The exercise lasts about 2 hours, which normally includes several nonfiring tracking runs followed by one or more firing runs. The target must maintain an altitude above 500 ft (152.4 m) for safety reasons, and is occasionally not destroyed during the exercise.

These activities occur within the TMAA and have the potential to disturb a marine mammal or marine mammal stock resulting in MMPA Level B harassment as defined for military readiness activities.

A typical scenario involving a DDG or FFG with 20mm Close-in-Weapon System (CIWS) is similar, except the ships involved engage the simulated threat aircraft or missile with the CIWS. CIWS-equipped ships can expend between 900 and 1,400 rounds per mount per firing run, for a total of up to five runs during the typical 2-hour exercise. The actual number of rounds expended during this exercise is dependent on the ship class, the CIWS model installed, and the available ammunition allowance.

There is also a Preventive Maintenance requirement to test fire CIWS prior to this exercise, called a Pre-action calibration firing (PACFIRE). A PACFIRE generally expends about 30 rounds per firing mount.

Air-to-Air MISSILEX

During an AAMEX, aircraft attack a simulated threat target aircraft with air-to-air missiles with the goal of destroying the target. Air-to-air missiles (approximately half of the missiles have live warheads and about half have an inert telemetry package) are fired from aircraft against aerial targets to provide aircrews with experience using aircraft missile firing systems and training on air-to-air combat tactics. Participating air units include fighter and fighter/attack aircraft firing a variety of air-to-air missiles. The main aerial targets are flares for heat-seeking missiles and Tactical Air Launched Decoys (TALDs) for radar-guided missiles. The targets typically are launched by other Navy aircraft that are participating in the exercise. Neither the flares nor TALDs are recovered after use. These activities occur within the TMAA. Similar activities could occur in the Air Force SUAs of the ATA, but their impacts are covered under other NEPA analyses (USAF 1995, USAF 1997, Army 1999, and Army 2004).

A typical scenario would involve a flight of two aircraft operating between 15,000 and 25,000 ft (4,572 and 7,620 m) and at a speed of about 450 kts (834 km/h) that approach a target from several miles away and, when within missile range, launch their missiles against the target. The missiles fired, to include the AIM-7 Sparrow, AIM-9 Sidewinder and AIM-120 AMRAAM, are not recovered. The target is either a TALD or a LUU-2B/B illumination paraflare (an illumination flare that hangs from a parachute). Both the TALDs and the paraflares are expended. These exercises last about one hour, and are conducted in the TMAA outside of 12 nm (22 km) and well above 3,000 ft (914 m). This training activity is not likely to disturb a marine mammal or marine mammal stock resulting in MMPA Level B harassment as defined for military readiness activities.

1.3.1.2 ASUW Training

In general, ASUW is the PMAR that addresses combat (or interdiction) activities in which aircraft, surface ships, and submarines employ weapons and sensors directed against enemy surface ships or boats. Air-to-surface ASUW is conducted by aircraft assets employing long-range attack maneuvers using precision guided munitions or aircraft cannons. ASUW also is conducted by warships employing naval guns and surface-to-surface missiles. Submarines attack surface ships using submarine-launched, anti-ship cruise missiles. Training in ASUW includes surface-to-surface gunnery and missile exercises, air-to-surface gunnery and missile exercises, and submarine missile launch events. Training generally involves expenditure of ordnance against a towed target. ASUW also encompasses maritime interdiction, that is, the interception of a suspect surface ship by a Navy ship for the purpose of boarding-party inspection or the seizure of the suspect ship.

Visit Board Search and Seizure/Vessels of Interest (VBSS/VOI)

VBSS/VOI missions are the principal type of Maritime Interdiction Operations (MIO) used by naval forces. Highly trained teams of armed personnel, wearing body armor, flotation devices, and communications gear are deployed from ships at sea into small Zodiac boats or helicopters to board and inspect ships and vessels suspected of carrying contraband. Once aboard, the team takes control of the bridge, crew, and engineering plant, and inspects the ship's papers and its cargo. VBSS missions are assumed to be nonhostile, but team members are trained and prepared to deal with noncooperation at all levels. When a helicopter is involved, either to provide cover or embark the inspection party, it is considered a Helicopter Visit Board Search and Seizure. These activities occur within the TMAA and are not likely to disturb a marine mammal or marine mammal stock resulting in MMPA Level B harassment as defined for military readiness activities.

Air-to-Surface MISSILEX

An air-to-surface MISSILEX involves fixed-winged aircraft and helicopter crews launching missiles at surface maritime targets, day and night, with the goal of training to destroy or disable enemy ships or boats. These activities occur within the TMAA; however, all missile launches would be simulated. MISSILEX activities are not likely to disturb a marine mammal or marine mammal stock resulting in MMPA Level B harassment as defined for military readiness activities.

For helicopter A-S MISSILEX, one or two MH-60R/S helicopters approach and acquire an at-sea surface target, which is then designated with a laser to guide an AGM-114 Hellfire missile to the target. The laser designator may be onboard the helicopter firing the hellfire, another helicopter, or another source. The helicopter simulates launching a missile from an altitude of about 300 ft against a specially prepared target with an expendable target area on a nonexpendable platform. The platform fitted with the expendable target could be a stationary barge, a remote-controlled speed boat, or a jet ski towing a trimaran whose infrared signature has been augmented with a heat source (charcoal or propane) to better represent a typical threat vessel. All missile firings would be simulated.

For an air-to-surface MISSILEX fired from fixed-wing aircraft, the simulated missile used is typically an AGM-84 Standoff Land Attack Missile-Expanded Response (SLAM-ER), an AGM-84 Harpoon, or an AGM-65 Maverick. A flight of one or two aircraft approach an at-sea surface target from an altitude between 40,000 ft (12,192 m) and 25,000 ft (7,620 m) for SLAM-ER or Harpoon, and between 25,000 ft (7,620 m) and 5,000 ft (1,524 m) for Maverick, complete the internal targeting process, and simulate launching the weapon at the target from beyond 150 nm (278 km) for SLAM-ER and from beyond 12 nm (22 km) for Maverick. The majority of unit level exercises involve the use of captive carry (inert, no release) training missiles; the aircraft perform all detection, tracking, and targeting requirements without actually releasing a missile. These activities occur within the TMAA and all missile launches would be simulated.

Air-to-Surface Bombing Exercise (BOMBEX)

During an air-to-surface BOMBEX, maritime patrol aircraft (MPA) or F/A-18 deliver free-fall bombs against surface maritime targets, with the goal of destroying or disabling enemy ships or boats.

A flight of one or two aircraft will approach the target from an altitude of between 15,000 ft (4,570 m) to less than 3,000 ft (914 m) while adhering to designated ingress and egress routes. Typical bomb release altitude is below 3,000 ft (914 m) and within a range of 1,000 yards (yd) (914 m) for unguided munitions, and above 15,000 ft (4,572 m) and in excess of 10 nm (18 km) for precision-guided munitions. Exercises at night will normally be done with captive carry (no drop) weapons because of safety considerations. Laser designators from own aircraft or a support aircraft are used to illuminate certified targets for use with lasers when using laser guided weapons. Bombs used could include BDU-45 (inert) or MK-82/83/84 (live and inert). These activities occur within the TMAA and have the potential to disturb a marine mammal or marine mammal stock resulting in MMPA Level B harassment as defined for military readiness activities. In the near future, the Navy will be transitioning all carrier based MK-80 series bombs to BLU 110, 111, and 117 live and inert bombs. The difference is that the BLU-series bombs contain insensitive (less likely to accidently explode) high explosives, which make them safer for carrier-based operations. All other attributes would remain the same.

Air-to-Surface GUNEX

Strike fighter aircraft and helicopter crews, including embarked NSW 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. These training activities have the potential to disturb a marine mammal or marine mammal stock resulting in MMPA Level B harassment as defined for military readiness activities.

For fixed-wing A-S GUNEX, a flight of two F/A-18 aircraft will begin a descent to the target from an altitude of about 3,000 ft (914 m) while still several miles away. Within a distance of 4,000 ft (1,219 m) from the target, each aircraft will fire a burst of about 30 rounds before reaching an altitude of 1,000 ft (305 m), then break off and reposition for another strafing run until each aircraft expends its exercise ordnance allowance of about 250 rounds from its 20mm cannon.

For rotary-wing A-S GUNEX, a single helicopter will carry several air crewmen needing gunnery training and fly at an altitude between 50 and 100 ft (15 to 30m) in a 300-ft (91-m) racetrack pattern around an at-sea target. Each gunner will expend about 200 rounds of 0.50 caliber (cal) and 800 rounds of 7.62mm ordnance in each exercise. The target is normally a noninstrumented floating object such as an expendable smoke float, steel drum, or cardboard box, but may be a remote-controlled speed boat or jet ski type target. The exercise lasts about 1 hour and occurs within the TMAA.

Surface-to-Surface GUNEX

These exercises train surface ship crews in high-speed surface engagement procedures against mobile (towed or self-propelled) seaborne targets. Both live and inert training rounds are used against the targets. The training consists of the pre-attack phase, including locating, identifying, and tracking the threat vessel, and the attack phase in which the missile is launched and flies to the target. In a live-fire event, aircraft conduct a surveillance flight to ensure that the range is clear of nonparticipating ships. These activities occur within the TMAA and have the potential to disturb a marine mammal or marine mammal stock resulting in MMPA Level B harassment as defined for military readiness activities.

For S-S GUNEX from a Navy ship, gun crews engage surface targets at sea with their main battery 5-inch and 76mm guns as well as smaller surface targets with 25mm, 0.50-caliber (cal), or 7.62mm machine guns, with the goal of disabling or destroying the threat target. For a surface-to-surface GUNEX from a Navy small boat, the weapon used is typically a 0.50 cal, 7.62-mm or 40-mm machine gun.

The number of rounds fired depends on the weapon used for S-S GUNEX. For 0.50-cal, 7.62mm, or 40mm ordnance, the number of rounds is approximately 200, 800, and 10 rounds respectively. For the ship main battery guns, the gun crews typically fire approximately 60 rounds of 5-inch or 76mm ordnance during one exercise. These activities occur within the TMAA.

Maritime Interdiction (MI)

MI is a coordinated defensive preplanned attack against multiple sea-borne and air targets using airborne and surface assets with the objective of delivering a decisive blow to enemy forces. These exercises typically involve all the assets of the CSG and Joint forces in an attempt to neutralize the threat. Weapons firing is simulated, and the exercise occurs exclusively within the TMAA each day. This activity is not likely to disturb a marine mammal or marine mammal stock resulting in MMPA Level B harassment as defined for military readiness activities.

Sea Surface Control (SSC)

SSC exercises involve aircraft, typically FA-18 hornets, performing reconnaissance of the surrounding battlespace. Under the direction of the Sea Combat Commander[6], the airborne assets investigate surface contacts of interest and attempt to identify, via onboard sensors or cameras, the type, course, speed, name, and other pertinent data about the ship of interest. Due to the curvature of the earth, surface assets are limited in their ability to see over the horizon. The airborne assets, due to their speed and altitude, can cover great distances in relatively short periods, and see far beyond the capabilities of the surface ship. This enables them to report contacts that cannot be seen by ships. By using airborne assets, the Sea Combat Commander, in effect, is able to see beyond the horizon and develop a clearer tactical picture well in advance. These activities occur within the TMAA and are not likely to disturb a marine mammal or marine mammal stock resulting in MMPA Level B harassment as defined for military readiness activities.

1.3.1.3 EC Training

In general, EC is the PMAR that aims to control the use of the electromagnetic spectrum and to deny its use by an adversary. Typical EC activities include threat avoidance training, signals analysis for intelligence purposes, and use of airborne and surface electronic jamming devices to defeat tracking systems. These activities are not likely to disturb a marine mammal or marine mammal stock resulting in MMPA Level B harassment as defined for military readiness activities.

EC exercises are conducted to prevent or reduce the effective use of enemy electronic equipment and ensure the continued use of friendly electronic equipment, including command and control capabilities. During EC training, appropriately configured aircraft fly threat profiles against ships so that the ship's crews are trained to detect electronic signatures of various threat aircraft and counter the jamming of the ship's own electronic equipment by the simulated threat.

Electronic Support (ES) provides the capability to intercept, identify, and locate enemy emitters while Electronic Attack (EA) employs tactics, such as electronic jamming, to prevent or reduce effective use of enemy electronic equipment and command and control capability. EA and ES are subsets of EC. Typical EC activities include threat-avoidance training, signals analysis, and use of airborne and surface electronic jamming devices to defeat tracking radar systems. During these 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. These activities occur within the TMAA. Additionally, this activity can occur in and on the Air Force SUA and Army training lands of ATA. When conducted in the Air Force SUA and Army training lands, these activities and their impacts are covered under other NEPA analyses (USAF 1995, USAF 1997, Army 1999, and Army 2004).

Chaff Exercise

Ships, fixed-winged aircraft, and helicopters deploy chaff to disrupt threat targeting and missile guidance radars and to defend against an attack. This activity is not likely to disturb a marine mammal or marine mammal stock resulting in MMPA Level B harassment as defined for military readiness activities.

The chaff exercise trains aircraft in the use and value of chaff to counter an enemy threat. Radiofrequency chaff is an electronic countermeasure designed to reflect radar waves and obscure aircraft, ships, and

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[6] The Sea Combat Commander is the individual who has the overall responsibility for defending the CSG against surface threats.

other equipment from radar tracking sources. Chaff is released or dispensed from military vehicles in cartridges or projectiles that contain millions of chaff fibers. Chaff is composed of an aluminum alloy coating on glass fibers of silicon dioxide. These aluminum-coated glass fibers (about 60 percent silica and 40 percent aluminum by weight) range in lengths of 0.8 to 7.5-cm with a diameter of about 40 micrometers. When deployed, a diffuse cloud of fibers undetectable to the human eye is formed. Chaff is a very light material that can remain suspended in air anywhere from 10 minutes to 10 hours. 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. These activities occur within the TMAA. Additionally, this activity can occur in and on the Air Force SUA and Army training lands of ATA. When conducted in the Air Force SUA and Army training lands, these activities and their impacts are covered under other NEPA analyses (USAF 1995, USAF 1997, Army 1999, and Army 2004).

Counter Targeting

A Counter Targeting exercise is a coordinated, defensive activity utilizing surface and air assets, that attempts to use jamming and chaff to show a false force presentation to inbound surface-to-surface platforms. During these exercises, EA-6B jamming aircraft will position itself between the CSG assets and the threat and jam the radar systems of potential hostile surface units. CSG ships will launch chaff to create false targets that saturate the threat radars return, thus masking their true position. These activities occur within the TMAA and are not likely to disturb a marine mammal or marine mammal stock resulting in MMPA Level B harassment as defined for military readiness activities.

1.3.1.4 NSW Training

In general, NSW forces (Sea, Air, Land [SEALs] and Special Boat Units [SBUs]) train to conduct military activities in five Special Operations mission areas: unconventional warfare, direct action, special reconnaissance, foreign internal defense, and counterterrorism. NSW training involves specialized tactics, techniques, and procedures, employed in training events that could include insertion/extraction activities using parachutes, rubber boats, or helicopters and other equipment. Activities associated with NSW are not likely to disturb a marine mammal or marine mammal stock resulting in MMPA Level B harassment as defined for military readiness 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 exercises train forces to insert and extract personnel and equipment day or night. There are a number of different insertion or extraction techniques that are used depending on the mission and tactical situation. NSW personnel conduct insertion/extraction exercises using helicopters and other equipment. These activities take place in existing Air Force SUA and Army training lands. When conducted in the Air Force SUA and Army land ranges, these activities and their impacts are covered under other NEPA analyses (USAF 1995, USAF 1997, Army 1999, and Army 2004). These activities are not likely to disturb a marine mammal or marine mammal stock resulting in MMPA Level B harassment as defined for military readiness activities.

1.3.1.5 STW Training

In general, Strike Warfare is the PMAR that addresses combat (or interdiction) activities by air and surface forces against hostile land based forces and assets. STW activities include training of fixed-wing fighter/attack aircraft in delivery of precision guided munitions, nonguided munitions, rockets, and other ordnance against land targets in all weather and light conditions. Training events typically involve a strike mission with a flight of four or more aircraft. The strike mission practices attacks on "long-range targets" (i.e., those geographically distant from friendly ground forces), or close air support of targets within close range of friendly ground forces. Laser designators from aircraft or ground personnel may be employed for delivery of precision-guided munitions. Some strike missions involve no-drop events in which prosecution of targets is practiced, but video footage is often obtained by onboard sensors. Strike exercises occur on the land and air training ranges as identified in the Air Force Alaska MOAs EIS, (USAF 1995) and their impacts are covered under its environmental analysis. This training is not likely to disturb a marine mammal or marine mammal stock resulting in MMPA Level B harassment as defined for military readiness activities.

Air-to-Ground BOMBEX

Air-to-ground bombing exercises consist of fixed-winged strike fighter aircraft that deliver bombs and rockets against land targets, day or night, with the goal of destroying or disabling enemy vehicles, infrastructure, and personnel. Typically, a flight of two to four aircraft will depart the aircraft carrier and fly inland at high altitude (greater than 30,000 ft [9,144 m]). The flight will approach the inland target from an altitude of between 15,000 ft (4,572 m) to less than 3,000 ft (914 m) and, 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 (914 m) and within a range of 1,000 yards (yd) (914 m) for unguided munitions or above 15,000 ft (4,572 m) and may be in excess of 10 nm (18 km) for precision-guided munitions. Exercises at night will normally be done with captive carry (no drop) weapons because of safety considerations. 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 1 hour. These activities take place in the inland SUA of the Air Force and on the Army land ranges of the ATA, where their impacts are covered under other NEPA analyses (USAF 1995, USAF 1997, Army 1999, and Army 2004). This training is not likely to disturb a marine mammal or marine mammal stock resulting in MMPA Level B harassment as defined for military readiness activities.

Personnel Recovery

PR is a strike warfare activity with the purpose of training aircrews to locate, protect, and evacuate downed aviation crew members. In a hostile environment, this exercise becomes a Combat Search and Rescue (CSAR) mission. The activity can include reconnaissance aircraft to find the downed aircrew, helicopters to conduct the rescue, and fighter aircraft to perform close air support to protect both the downed aircrews and the rescue helicopters. These activities can take place throughout the ATA. Impacts from these activities that occur in the inland SUA of the Air Force and on the Army training lands of the ATA are covered under other NEPA analyses (USAF 1995, USAF 1997, Army 1999, and Army 2004). This training is not likely to disturb a marine mammal or marine mammal stock resulting in MMPA Level B harassment as defined for military readiness activities.

1.3.1.6 Other Training

Deck Landing Qualifications

Deck Landing Qualifications (DLQs) provide training for helicopter crews to land on ships underway at sea. Perhaps the most demanding mission of any aviator is landing an aircraft aboard a ship. The mission is made even more difficult when these activities are required at night or in rough sea states. Further compounding the situation during Northern Edge exercises is the fact that aircrew from the Air Force, Army, and U.S. Coast Guard, who do not normally perform DLQs, use this venue to practice helicopter DLQs onboard naval vessels. For safety, the Navy has strict guidelines and rules on frequency and duration between landings. As this is not a normal activity for Air Force, Army, and USCG helicopter crews, the number and duration of particular DLQs that occur during a joint training exercise can vary dramatically.

DLQ activities take place on an underway Navy or USCG ship. The activities takes place in both day and night, and could involve more than one helicopter over a period of several hours. The crew that is receiving the training typically departs from a shore facility and flies out to sea to make an approach and landing aboard the ship. After the required number of landings is completed, the helicopter either remains aboard ship or departs for shore. These activities take place in the TMAA. DLQ training is not likely to disturb a marine mammal or marine mammal stock resulting in MMPA Level B harassment as defined for military readiness activities.

Naval Force Structure

The Navy has established policy governing the composition and required mission capabilities of deployable naval units, focused on maintaining flexibility in the organization and training of forces. Central to this policy is the ability of naval forces of any size to operate independently or to merge into a larger naval formation to confront a diverse array of challenges. Thus, individual units may combine to form a Strike Group, and Strike Groups may combine to form a Strike Force. Composition of the Strike Groups and Strike Forces is discussed below.

“Baseline” Naval Force Composition

Navy policy defines the “baseline” composition of deployable naval forces. The baseline is intended as an adaptable structure to be tailored to meet specific requirements. Thus, while the baseline composition of a CSG calls for a specified number of ships, aviation assets, and other forces, a given CSG may include more or fewer units, depending on their mission. The baseline naval force structures established by Navy policy for a CSG are: One Aircraft Carrier; One Carrier Air Wing consisting of four Strike Fighter squadrons, one Electronic Combat squadron, two Combat Helicopter squadrons, and two logistics aircraft; Five Surface Combatant Ships where “Surface Combatant” refers to guided missile cruisers, destroyers, and frigates, and future DDG 1000 and Littoral Combat Ship platforms; one attack submarine; and one logistic support ship.

1.3.2 Force Structure Changes

The Navy will train with new ships, aircraft, and systems as they become operational in the Fleet. Several future platforms and weapon systems have been identified that are in development, and are likely to be incorporated into Navy training requirements within the 10-year planning horizon. Several of these new technologies are in early stages of development, and thus specific concepts of operations, operating parameters, or training requirements are not yet available. However, when made available, information will be incorporated into the development of ongoing environmental documents.

Specific force structure changes and their impact on training within the GOA are based on the Navy’s knowledge of future requirements for the use of new platforms and weapons systems and based on the level of information available to evaluate potential environmental impacts. Therefore, this LOA request, to the extent feasible, will evaluate potential environmental impacts associated with the introduction of the following platforms and weapon systems. Should additional requirements for the use of platforms and weapon systems be needed, separate NEPA and environmental documentation would be required to analyze potential impacts.

1.3.3 New Platforms/Vehicles

1.3.3.1 EA-18G Growler

The EA-18G Growler is an electronic combat version of the FA-18 E/F that will replace the EA-6B Prowler. Analysis within this LOA request of any EA-6B activity also considers the potential impacts of future activities with the EA-18G. The Growler will have an integrated suite of advanced communications and EC systems that will initially be centered on the Improved Capability (ICAP) III system, but will also include tactical jamming pods, a radar receivers wingtip pods, an advanced crew station, the Airborne Electronically Scanned Array (AESA) multimode radar, and a communications receiver and jammer. The EA-18G will have a limited self-protection capability requiring aircrews to train for offensive air-to-air missile engagements and conduct missile exercises. The advanced capabilities of the Growler will require greater standoff ranges and broader frequency spectrum access than current systems. As a replacement for existing aircraft, the introduction of this system will not result in any new or additional effects. Use of the EA-18G is not likely to disturb a marine mammal or marine mammal stock resulting in MMPA Level B harassment as defined for military readiness activities.

1.3.3.2 Guided Missile Submarine (SSGN)

Four *Ohio*-class *Trident* submarines that were previously scheduled for inactivation during Fiscal Years 2003 and 2004 were converted to SSGNs over a 5-year period ending in 2008. The primary missions of the SSGN are land attack (STW) and Special Operations Forces (SOF) insertion and support. Secondary missions are the traditional attack submarine missions of Intelligence, Surveillance, and Reconnaissance (ISR), battle space preparation, and sea control.

These ships are armed with up to 154 Tomahawk or Tactical Tomahawk land attack missiles. They have the ability to carry and support a team of 66 SOF personnel for up to 90 days as compared to 15 days for a SOF outfitted Fast Attack Submarine (SSN). Clandestine insertion and retrieval of these SOF is enhanced by the ability to host dual dry deck shelters or Advanced Seal Delivery System. Each SSGN is able to conduct a variety of peace-time, conventional deterrent and combat activities all within the same deployment. The first SSGNs became operational in Fiscal Year (FY) 2007. Their use in Alaska waters will not include the strike mission, but may involve clandestine special operations. As a replacement for existing submarines, the introduction of this system will not result in any new or additional effects. Use of SSGN in the TMAA is not likely to disturb a marine mammal or marine mammal stock resulting in MMPA Level B harassment as defined for military readiness activities.

1.3.3.3 P-8 Poseidon MMA

The P-8A Poseidon MMA is the Navy's replacement for the aging P-3 Orion aircraft. It is a modified Boeing 737-800ERX that brings together a highly reliable airframe and high-bypass turbo fan jet engine with a fully connected, state-of-the-art open architecture mission system. This combination, coupled with next-generation sensors, will dramatically improve ASW and ASUW capabilities. The MMA will ensure the Navy's future capability in long-range maritime patrol. It will be equipped with modern ASW, ASUW, and ISR sensors. In short, MMA is a long-range ASW, ASUW, ISR aircraft that is capable of broad-area, maritime, and littoral activities. Initial Operational Capability (IOC) is expected in FY 2013. As a replacement for existing aircraft, the introduction of this system will not result in any new or additional effects. Use of P-8 aircraft is not likely to disturb a marine mammal or marine mammal stock resulting in MMPA Level B harassment as defined for military readiness activities.

1.3.3.4 DDG-1000 Zumwalt Class Destroyer

The DDG-1000 Destroyer is the lead ship in a class of next-generation, multimission surface combatants tailored for land attack and littoral dominance, with capabilities designed to defeat current and projected threats as well as improve Strike Group defense. This class of ship is undergoing design and development, and is not expected to be introduced to the Fleet before 2012. Training activities involving this class of ship are addressed in this LOA request. As a replacement for an existing ship, the introduction of this system will not result in any new or additional effects. Use of DDG-1000 in the TMAA is not likely to disturb a marine mammal or marine mammal stock resulting in MMPA Level B harassment as defined for military readiness activities.

1.3.3.5 Fire Scout UAS

The Fire Scout UAS is a Vertical Takeoff and Landing UAS (VTUAS) designed to operate from air-capable ships, carry modular mission payloads (ordnance), and operate using the Tactical Control System and Tactical Common Data Link. It provides day/night real-time ISR and targeting as communication-relay and battlefield management capabilities to support Littoral Combat Ship (LCS) mission areas of ASW, MIW, and ASUW. Operation of these systems could produce new requirements for the GOA in terms of airspace and frequency management. Fire Scout will be fielded in early LCS versions. Use of the Fire Scout UAS is not likely to disturb a marine mammal or marine mammal stock resulting in MMPA Level B harassment as defined for military readiness activities.

1.3.3.6 Broad Area Maritime Surveillance UAS

The BAMS UAS is being designed to support persistent, worldwide access through multisensor, maritime ISR providing unmatched awareness of the battlespace. It will support a spectrum of Fleet missions serving as a distributed ISR node in the overall naval environment. These missions include maritime surveillance, Battle-Damage Assessment (BDA), port surveillance and homeland security support, MIW, MI, Surface Warfare (SUW), counter drug activities, and battlespace management. The BAMS will operate at altitudes above 40,000 ft (12.2 km), above the weather, and above most air traffic to conduct continuous open-ocean and littoral surveillance of targets as small as exposed submarine periscopes. Operation of these systems could produce new requirements for range complexes in terms of airspace and frequency management. IOC is anticipated for FY09. Maritime surveillance is not likely to disturb a marine mammal or marine mammal stock resulting in MMPA Level B harassment as defined for military readiness activities.

1.3.3.7 Navy Unmanned Combat Air System (N-UCAS)

The N-UCAS (Grumman X-47B) program is a Navy effort to demonstrate the technical feasibility, military utility, and operational value of an aircraft carrier based, networked system of high performance, weaponized UASs to effectively and affordably execute 21st century combat missions, including Suppression of Enemy Air Defenses (SEAD), surveillance, and precision strike within the emerging global command, and control architecture. Operation of these systems could produce new requirements for range complexes in terms of airspace, frequency management, and target sets. IOC of these systems has not yet been established. Activities associated with the use of this system are not likely to disturb a marine mammal or marine mammal stock resulting in MMPA Level B harassment as defined for military readiness activities.

1.3.4 New Sensor Systems

Under the Proposed Action, the only sensor systems being introduced at this time that warrant discussion in this LOA request are MAC (SSQ-125) sonobuoy and systems associated with the use of the Portable Undersea Tracking Range (PUTR).

1.3.4.1 SSQ-125 Multistatic Active Coherent (MAC) Sonobuoy

The Multistatic Active Coherent (MAC)[7] Sonobuoy program examines improvements in both long-range shallow and deep water ASW search using active sources. The proposed MAC system is similar to the Extended Echo Ranging/Improved Extended Echo Ranging (EER/IEER) system. The MAC system will use the same Air Deployed Active Receiver (SSQ-101) sonobuoys as the acoustic receiver and will be used for a large area ASW search capability in both shallow and deep water. However, instead of using an explosive SQS-110A as an impulsive source for the active acoustic wave, the MAC system will use a battery powered (electronic) source for the SSQ-125 sonobuoy. The output and operational parameters for the SSQ-125 sonobuoy (source levels, frequency, wave forms, etc.) are classified. Also used will be the passive Vertical Line Array Directional Frequency Analysis and Recording (VLAD) Sonobuoy (SSQ-77). Use of MAC has the potential to disturb a marine mammal or marine mammal stock resulting in MMPA Level B harassment as defined for military readiness activities.

Current planning suggests the MAC will begin to incrementally replace use of EER/IEER starting in 2011 with no further use of the EER/IEER system beginning in 2015 and beyond. Once the date of deployment has been finalized and operational parameters for MAC are established, Navy will provide supplemental analysis to address the reduction of potential marine mammal exposures by replacement of EER/IEER (explosives) with MAC. In the interim, this LOA request includes the use of MAC given that the analysis for EER/IEER is an overestimate of potential MAC MMPA Level B impacts from TTS and MMPA Level A impacts and, therefore, is conservative[8].

1.3.5 New Instrumentation Technology

New technologies will provide for portable systems with the capability to score, track, and provide feedback on underwater events. The PUTR is a self-contained, portable, undersea tracking capability that employs modern technologies to support coordinated undersea warfare training in numerous locations. PUTR will be available in two variants to support both shallow and deep water remote exercises in keeping with Navy requirements to exercise and evaluate weapons systems and crews in the environments that replicate the potential combat area. The system will be capable of tracking submarines, surface ships, weapons, targets, and unmanned undersea vehicles and distribute the data to a data processing and display system, either aboard ship, or at a shore site.

1.3.5.1 PUTR Components

The PUTR would be deployed to support ASW training in the TMAA. The PUTR would temporarily place hydrophones in an area on the seafloor from 25-100 nm^2 (46.3-185.2 square-kilometer [km^2]) or smaller and to provide high fidelity feedback and scoring of crew performance during ASW training activities. When training is complete, the components of the PUTR would be recovered. Use of PUTR has

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[7] The SQQ-125 Multistatic Active Coherent (MAC) sonobuoy was formerly refered to as the Advanced Extended Echo Ranging(AEER) sonobuoy system.

[8] An EER/IEER sonobuoy carries two explosive charges. When deployed from aircraft, every EER/IEER sonobuoy will result in two explosive impulses either as a result of a command to “ping” or when scuttled at the end of the training event. MAC, in contrast, has an electronic source and will only “ping” when commanded to do so. Not every MAC buoy will be command activated before being scuttled at the end of the training event.

the potential to disturb marine mammals or marine mammal stocks resulting in MMPA Level B harassment as defined for military readiness activities.

No onshore construction would take place. Seven electronics packages, each approximately 3 ft (0.9 m) long by 2 ft (0.6 m) in diameter, would be temporarily installed on the seafloor by a range boat, in water depths greater than 600 ft (182 m). The anchors used to keep the electronics packages on the seafloor would be either concrete or sand bags, which would be approximately 1.5 by 1.5 ft (0.45 by 0.45 m) and would weigh approximately 300 pounds. Operation of this range requires that underwater participants transmit their locations via pingers (see "Range Tracking Pingers" below). Each package consists of a hydrophone that receives pinger signals, and a transducer that sends an acoustic "uplink" of locating data to the range boat. The uplink signal is transmitted at 8.8 kHz, 17 kHz, or 40 kHz, at a source level of 190 decibels (dB). The PUTR system also incorporates an underwater voice capability that transmits at 8-11 kHz and a source level of 190 dB. Each of these packages is powered by a D cell alkaline battery. After the end of the exercise the electronic packages would be recovered and the anchors would remain on the seafloor. No additional ASW activity is proposed as a result of PUTR use.

Range tracking pingers would be installed on ships, submarines, and ASW targets when ASW TRACKEX training is conducted on the PUTR. A typical range pinger generates a 12.93-kHz sine wave in pulses with a maximum duty cycle of 30 milliseconds (3 percent duty cycle) and has a design power of 194 dB re 1 micro-Pascal at 1 meter. Although the specific exercise, and number and type of participants will determine the number of pingers in use at any time, a maximum of three pingers and a minimum of one pinger would be used for each ASW training activity. On average, two pingers would be in use for 3 hours each during PUTR operational days. No additional ASW activity is proposed as a result of PUTR use.

1.3.6 Proposed New Training Activities within the Alaska Training Areas

1.3.6.1 ASW Sonar Use

Various types of active sound sources are used by the Navy for purposes such as to determine water depth, locate mines, transmit data, and identify, track, and target submarines. One of the most common active sources is sonar. Sonar uses an underwater transducer or speaker to generate sound waves. The sound waves travel until they encounter an object and are reflected in various directions. Some of the reflected waves return to the hydrophone or receiver, where they are converted back into electric signals, amplified and displayed. A careful interpretation of the reflected sound can provide the direction and distance of the object, as well as its size and speed. This is accomplished through "echo ranging," which measures the time it takes for a sound wave to travel from the transducer, reflect off the object, and return to the receiver. Active sonar is critical for locating and tracking submarines because it provides both bearing (direction) and range (distance) to the detected contact. For the purpose of MMPA compliance, the Navy has segmented active sound sources as defined below into low-, mid-, and high-frequency.

- A High-frequency active (HFA) source operates at frequencies greater than 10 kHz. At higher acoustic frequencies, sound rapidly dissipates in the ocean environment, resulting in short detection ranges, typically less than 5 nm, for systems using this frequency range. For example, high-frequency sonar is used by the Navy primarily for determining water depth, locating mines, and guiding torpedoes which are all short range applications. Use of HFA sources as a continuing action will occur in the TMAA.
- Mid-frequency active (MFA) sources operates between 1 kHz and 10 kHz, with sonar detection ranges up to 10 nm (19 km). Because of this detection ranging capability, sonar in this frequency range provides an optimal balance of detection range and resolution and as such is the Navy's primary tool for conducting ASW. Many ASW experiments and exercises have demonstrated that

this improved capability for long range detection of adversary submarines before they are able to conduct an attack is essential to U.S. ship survivability. Today, ASW is the Navy's #1 war-fighting priority. Navies across the world utilize modern, quiet, diesel-electric submarines which pose the primary threat to the Navy's ability to perform a number of critically necessary missions. Extensive training is necessary if Sailors, ships, and strike groups are to gain proficiency in using MFA sonar. If a strike group does not demonstrate MFA sonar proficiency, it cannot be certified as combat ready. Use of MFA sonar and other MFA sources are proposed for use in the TMAA.

- Low-frequency sources operate below 1 kHz. Sonar in this frequency range is designed to detect extremely quiet diesel-electric submarines at ranges far beyond the capabilities of MFA sonars. There are currently only two ships in use by the Navy that are equipped with low-frequency sonar; both are ocean surveillance vessels operated by Military Sealift Command. While SURTASS low frequency active sonar was analyzed in a separate EIS/OEIS, use of low-frequency active sonar is not part of the planned training activities considered for the GOA. Use of other low frequency sources (such as the MK-39 EMATT) is proposed for use in the TMAA.

Unlike active sound sources, passive sonar or other passive devices only "listen" for sound waves generated or reflected by the subject of interest. Because no sound is introduced into the water when using passive systems, they can only indicate the presence, general direction, and character and movement of the sound source. Passive devices do not, therefore, provide accurate range to the source and can not be used exclusive of active sources when conducting ASW.

Tactical ASW sonar systems that deploy from certain classes of surface ships, submarines, helicopters, and fixed-wing MPA are identified in Table 1-2. Guided Missile surface ships (CG, DDG, FFG) and submarines are equipped with hull-mounted sonars (passive and active) mainly for the detection of submarines. Helicopters equipped with dipping sonar or sonobuoys are used to locate suspect submarines or submarine targets within the training area. In addition, fixed-wing aircraft are used to deploy both active and passive sonobuoys to search for, track, and attack submarines.

Table 1-2. ASW Sonar Systems and Platforms in the TMAA

System	Associated Platform/Use
AN/SQS-53	Guided Missile Destroyer (DDG) and Guided Missile Cruiser (CG) hull-mounted sonar
AN/SQS-56	Fast Frigate (FFG) hull-mounted sonar
AN/BQQ-10	Submarine hull-mounted sonar
AN/AQS-13 or AN/AQS-22	Helicopter dipping sonar
BQS-15	Submarine safety/navigation sonar
DICASS Sonobuoy (AN/SSQ-62)	Maritime Patrol Aircraft (MPA) deployed sonobuoys
IEER Sonobuoy (AN/SSQ-110A)	MPA deployed sonobuoys
MAC Sonobuoy (AN/SSQ-125)	MPA deployed sonobuoys

The named sonars listed (e.g., SQS-53, SQS-56, etc.) are meant to be representative of all the combat suite variants of the same system. In the case of the the SQQ-89 system, there are currently 14 variants for CG and DDG (represented by the SQS-53) and two variants of the system on FFGs represented by the SQS-56.

Sonar Systems Associated with Surface Ships. CGs, DDGs, and FFGs are equipped with MFA sonar as well as passive sonars for submarine detection and tracking, mine avoidance, and navigation. CG and DDG use the SQS-53 and FFG use the use the SQS-56 sonar system. All Navy ships have high-frequency sonar (fathometers) serving as depth finders but these are not currently regulated sound sources.

Sonar Systems Associated with Submarines. Submarines are equipped with high-frequency sonars (BQS-15 or BQQ-24) for use in navigation, detection of ice or other objects overhead, mine avoidance, and as a fathometer. Some submarines are also equipped with a variety of MFA and passive sonar systems that are used to detect and target enemy submarines, surface ships, for mine avoidance, and navigation. However, submarines rarely use active sonars (BQQ-10) during ASW or ASUW events and when they do, sonar pulses are very short and directed. Submarine use of sonar for ASW and ASUW training is possible in the TMAA. Submarines also have high-frequency sonar (fathometers) serving as depth finders, but these are not currently regulated sound sources.

Sonar Systems Associated with Aircraft. Aircraft sonar systems that would be deployed in the TMAA include sonobuoys from fixed and rotary wing aircraft and dipping sonar from helicopters. Sonobuoys are expendable devices used by aircraft for the detection of underwater acoustic energy and for conducting vertical water column temperature measurements. The majority of sonobuoys deployed are passive, but some can generate active acoustic signals, as well as listen passively. Helicopters and MPA (P-3 or P-8 in approximately 2013) will deploy sonobuoys in the TMAA during an ASW exercise. Use of sonobuoys and dipping sonar have the potential to disturb a marine mammal or marine mammal stock resulting in MMPA Level B harassment as defined for military readiness activities.

The proposed action would include mid- and high-frequency sonar use, including 578 hours of SQS-53 and 52 hours of SQS-56 surface ship sonar, the BQQ-10 (48 hours) and BQS-15 (24 Hours) submarine sonars, 266 active SSQ-62 sonobuoys, and 192 dips of helicopter dipping sonar (Table 1-3).

Table 1-3. Annual Sonar Hours and Sources

	SQS 53 Sonar [a]	SQS-56 Sonar [a]	BQQ-10 Sonar [a]	BQS-15 Sonar [a]	SSQ-62 DICASS Sonobuoy[b]	AQS 22 Dipping Sonar[c]
Preferred Alternative	578	52	48	24	266	192

Notes: a = Number reflects hours of operations not total transmission time, representative for all variants of system. b = Number is counted by buoy, c = Number is counted as individual use "dips" of the system

1.3.6.2 Non-Sonar Acoustic Sources Used During Training

In addition to the use of mid- and high-frequency sonar, additional non-sonar acoustic sources used during training under the proposed action would include components of the Portable Undersea Tracking Range including MK-84 Range Tracking Pingers (80 ea) and Transponders (80 ea), plus MK-39 EMATT targets (12 ea) and SUS MK-84 signaling devices (24 ea) as shown in Table 1-4.

Table 1-4. Annual Non-Sonar Acoustic Sources

	MK-84 Range Tracking Pinger[a]	PUTR Transponder[a]	MK-39 EMATT targets[b]	SUS MK-84 signaling devices[b]
Preferred Alternative	80	80	12	24

Notes: a = This number reflects hours of operation for the PUTR system under average conditions and is not total transmission time of the components. b = Number is counted by device.

Other sound sources associated with Navy training activities may be used in the TMAA. The types of sound sources used in the TMAA are described in the following sections. Tables 1-5 and 1-6 provide a list of all Navy sources modeled and those not modeled.

Table 1-5. Acoustic Systems Modeled

ACOUSTIC SOURCE	FREQUENCY (kHz)	ASSOCIATED PLATFORM	SYSTEM DESCRIPTION
SQS-53 (all variants)	MF	DDG and CG hull-mounted sonar (all variants)	Modeled as 70 percent in search mode and 30 percent track mode.
AQS-13; AQS-22	MF	Helicopter dipping sonar	AQS-22: 10 pings/dip, 30 seconds between pings) - also used to represent AQS-13.
SSQ-110A (IEER)	Impulsive	Helicopter and MPA deployed	Explosive source sonobuoy containing two 4.4 pound charges.
SQS-56	MF	FFG hull-mounted sonar	Modeled as 70 percent in search mode and 30 percent track mode.
BQQ-10, BQQ-5, BSY-1	MF	Submarine hull-mounted sonar	Two 1 sec pings @ 3.5 kHz at 235 dB per hour per event at 100 m depth.
BQS-15 or BQQ-24	HF	Submarine hull mounted sonar	20 pings in sequence per hour for 4 hours at 50 meters per event.
SSQ-62 (DICASS)	MF	Helicopter and MPA deployed	Tonal sonobuoy (12 pings, 30 seconds between pings.
MK-39 EMATT or MK-30	LF	Target	900 Hz at 130 db for four hours (continuous) at a speed of 5 kts and a depth of 100 meters.
SUS MK-84	MF	Sonobuoy	Four used per event at 35 pings each, 3.4 kHz @ 160 dB/uPa for 2 sec at 50 meters depth.
PUTR Pinger MK-84	HF	Ships, submarines, targets	Three (3) pingers used in each ASW tracking exercise. Two (2) on surface ships (7 m depth) and one (1) on a target or submarine at 100 m depth. Ping duration 15 msec @ 12.9 kHz. Ping rate once every 2 seconds.
PUTR Transponder	MF	Fixed PUTR hardware	30 pinger signals per minute (per pinger), an average of 19 (63%) pinger signals will be received by four transponders and therefore generate 76 pinger signal reports from transponders to the hub (76 reports, per pinger, per minute; Each report is assumed to be 15 milliseconds duration 186 dB @ 8.8 kHz.
MK-48 Torpedo	HF	Submarine fired torpedo	Active for 15 minutes per torpedo run – To be used only during SINKEX.

Table 1-6. Acoustic Systems Not Modeled

ACOUSTIC SOURCE	FREQUENCY (kHz)	ASSOCIATED PLATFORM	SYSTEM DESCRIPTION
Surface Ship Fathometer	12 kHz	Depth finder on surface ships	System is not unique to military and operates identically to any commercially available bottom sounder.
Submarine Fathometer	12 kHz	Depth finder on submarine	System is not unique to military and operates identically to any commercially available bottom sounder.
Torpedoes (MK-46, MK-54)	HF	Submarine, surface ship, and aircraft fired torpedoes	Not proposed for use in the TMAA.
Kingfisher (SQS-53 & SQS-56)	MF	Surface ship	Object and mine detection mode for surface ship sonar. Not proposed for use in the TMAA.
SQQ-32	HF	Surface ship	Mine detection and countermeasure. Not proposed for use in the TMAA.
AQS-14, AQS-20, AQS-24	>200 kHz	Helicopter	Deployed for mine detection. Not proposed for use in the TMAA.
SLQ-25 (NIXIE)	MF	DDG, CG, and FFG	Towed acoustic countermeasure. Not proposed for use in the TMAA
Acoustic Detection Countermeasures (MK-1, MK-2, MK -3, MK -4)	MF	Countermeasure package deployed during some ASW events	Deployed to counter torpedoes. Not proposed for use in the TMAA
SQR-19	Passive	System is a passive towed array emitting no active sonar.	An array towed behind a surface ship
TB-16/23/29/33	Passive	System is a passive towed array emitting no active sonar.	An array towed behind a submarine
SSQ-53 (DIFAR); SSQ-101 (ADAR); SQS-77 (VLAD)	Passive	Aircraft (helicopter or MPA)	Passive sonobuoys deployed from helicopter or MPA use of passive sonobuoys emit no active sonar
SSQ-125 (MAC)	MF	Future: MPA deployed tonal sonobuoy	Replacement for SSQ-110A uses electronic, not explosive, sound soure. Date of introduction and parameters for use in GOA not known; Analysis of system deferred until operational data available
WSQ-9; ACOMMS	MF/HF	Surface ships, submarines, buoys	Operational use of passive hydrophones and arrays and active transducers as system components used to transmit voice and data underwater for safety, data sharing, and communication.
Unmanned Underwater Vehicle	MF/HF	Underwater unmanned vehicles	Data collection telemetry and mapping sonars may be active sources.

Notes:
MAC = Multistatic Active Coherent
DICASS = Directional Command Activated Sonobuoy
FFG = Guided Missile Frigate
IEER = Improved Extended Echo Ranging
MPA = Maritime Patrol Aircraft
CG = Guided Missile Carrier
EMATT = Expendable Mobile ASW Training Target
GOA = Gulf of Alaska
kHz = kilohertz
PUTR = Portable Undersea Tracking Range
DDG = Guided Missile Destroy
HF = High-frequency
MF = Mid-frequency

1.3.6.3 ASW Training

ASW Tracking Exercise (TRACKEX) trains aircraft, ship, and submarine crews in tactics, techniques, and procedures for search, detection, localization, and tracking of submarines with the goal of determining a firing solution that could be used to launch a torpedo and destroy the submarine. Use of torpedoes is not a proposed activity in the TMAA, with the exception of the SINKEX. A typical unit-level exercise involves one (1) ASW unit (aircraft, ship, or submarine) versus one (1) target (usually a MK-39 Expendable Mobile ASW Training Target [EMATT] or a live submarine). The target may be nonevading while operating on a specified track or fully evasive. ASW activities will include the use of MFA and HFA sonar. Participating units use active and passive sensors, including hull-mounted sonar, towed arrays, dipping sonar, variable depth sonar, and sonobuoys for tracking. Details of these operational parameters (duration of the event, number of occurrences, etc.) are provided in Appendix B.

Helicopter ASW TRACKEX. A helicopter ASW TRACKEX typically involves one or two MH-60R helicopters using both passive and active sonar for tracking submarine targets. For passive tracking, the MH-60R will deploy patterns of passive sonobuoys that will receive underwater acoustic signals, providing the helicopter crew with locating information on the target. Active sonobuoys may also be used. An active sonobuoy, as in any active sonar system, emits an acoustic pulse that travels through the water, returning echoes if any objects, such as a submarine, are within the range of acoustic detection. For active sonar tracking, the MH-60R crew will rely primarily on its AQS-22 Dipping Sonar. The sonar is lowered into the ocean while the helicopter hovers within 50 ft (15m) of the surface. Similar to the active sonobuoy, the dipping sonar emits acoustic energy and receives any returning echoes, indicating the presence of an underwater object. Use of dipping sonar has the potential to disturb a marine mammal or marine mammal stock resulting in MMPA Level B harassment as defined for military readiness activities.

The target for this exercise is either an EMATT or live submarine which may be either nonevading and assigned to a specified track or fully evasive depending on the state of training of the helicopter crew. A Helicopter TRACKEX usually takes 2 to 4 hours. No torpedoes are fired during this exercise. A total of 192 AQS-22 “dips” annually were analyzed for potential acoustic impacts under the proposed training activities.

MPA[9] *ASW TRACKEX*. During these exercises, a typical scenario involves a single MPA dropping sonobuoys, from an altitude below 3,000 ft (914 m), into specific patterns designed for both the anticipated threat submarine and the specific water conditions. These patterns vary in size and coverage area based on anticipated threat and water conditions. Typically, passive sonobuoys will be used first, so the threat submarine is not alerted. Active sonobuoys will be used as required either to locate extremely quiet submarines or to further localize and track submarines previously detected by passive buoys. Use of sonobuoys has the potential to disturb a marine mammal or marine mammal stock resulting in MMPA Level B harassment as defined for military readiness activities.

The MPA will typically operate below 3,000 ft (914 m) to drop sonobuoys, will sometimes be as low as 400 ft (122 m), then it may climb to several thousand feet after the buoy pattern is deployed. The higher altitude allows monitoring the buoys over a much larger search pattern area. The target for this exercise is either an EMATT or live submarine which may be either non-evading and assigned to a specified track or fully evasive depending on the state of training of the MPA. An MPA TRACKEX usually takes 2 to 4 hours. No torpedoes will be used during this exercise in the TMAA. The use of a total of 266 DICASS sonobuoys annually were analyzed for potential acoustic impacts under the proposed training activities.

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[9] MPA currently refers to the P-3C Orion aircraft. The P-8 Multi-Mission Maritime Aircraft is schedule to replace the P-3C as the Navy’s MPA.

EER ASW Exercises. This exercise is an at-sea flying event designed to train MPA crews in the deployment and use of the EER sonobuoy systems. This system uses the SSQ-110A as the signal source and the SSQ-77 as the receiver buoy. This activity differs from the MPA ASW TRACKEX in that the SSQ-110A sonobuoy uses two explosive charges per buoy for the acoustic source. Other active sonobuoys use an electrically generated "ping." Use of explosive sonobuoys has the potential to disturb a marine mammal or marine mammal stock resulting in MMPA Level B harassment as defined for military readiness activities.

A typical EER exercise lasts approximately 6 hours. The aircrew will first deploy 16 to 20 SSQ-110A sonobuoys and 16 to 20 passive sonobuoys in 1 hour. For the next 5 hours, the sonobuoy charges will be detonated, while the EER system analyzes the returns for evidence of a submarine. This exercise may or may not include a practice target. Use of a total of 80 SSQ-110 (two explosions per buoy) sonobuoys annually were analyzed for potential acoustic impacts under the proposed training activities.

In the future, the SSQ-125 MAC sonobuoy will be deployed in the TMAA as a replacement for the SSQ-110 in EER exercises. When the date and operational parameters for this sonobuoy are finalized, supplementary analysis will be undertaken as required.

ASW TRACKEX (Surface Ship). Surface ships operating in the TMAA would use hull-mounted active sonar to conduct ASW Tracking exercises. Typically, this exercise would involve the coordinated use of other ASW assets, to include MPA, helicopters, and other ships. A total of 578 hours of SQS-53 and 52 hours of SQS-56 sonar annually were analyzed for potential acoustic impacts under the proposed training activities. Acoustic cumulative and synergistic effects are incorporated into the modeling as detailed in Appendix B. Use of active sonar by surface ships for ASW has the potential to disturb a marine mammal or marine mammal stock resulting in MMPA Level B harassment as defined for military readiness activities.

ASW or ASUW (Submarine). During these exercises submarines use passive 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. However, no torpedoes are fired during this exercise. Submarines also use their high frequency sonar for object avoidance and navigation safety. Sonar use by submarines has the potential to disturb a marine mammal or marine mammal stock resulting in MMPA Level B harassment as defined for military readiness activities.

1.3.6.4 Torpedoes

Torpedoes are the primary ASW weapon used by surface ships, aircraft, and submarines; however, with the exception of the SINKEX, torpedoes will not be used in the TMAA during the proposed training activities.

1.3.6.5 Training Targets

ASW training targets are used to simulate target submarines in the absence of an actual submarine. These training targets 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 fields to trigger magnetometers. Two ASW training target types are used in the TMAA: the MK-30, which is recovered after each use and the MK-39 EMATT, which is an expendable device. Approximately 40 EMATT may be expended annually during training in the TMAA. A small percentage of these annual EMATT may be replaced by the more costly yet recoverable MK-30. Use of training targets is not likely to disturb a marine mammal or marine mammal stock resulting in MMPA Level B harassment as defined for military readiness activities.

Table 1-7 identifies training activities conducted in the TMAA that may have a potential to cause incidental harassment of marine mammals. These activities are analyzed for impacts in the subsequent sections of this LOA request.

Table 1-7. Summary of GOA TMAA Training Activities with Potential for Incidental Marine Mammal Harassment

Exercise Type	ASW – Helicopter or MPA	ASW Surface	ASW Submarine	EER/IEE R/AEER	MISSILEX (A-A; S-A)	GUNEX (A-S; S-S; S-A)	BOMBEX	SINKEX	Range Operations (PUTR)
Anticipated Takes	Yes	Yes	Yes	Yes	No	Yes	Yes	No	Yes
Explosion in or on water	No	No	No	Yes	No	Yes	Yes	Yes	No
Length of Exercise	2-4 hrs	5 to 7 days	2-3 days	6 hours	1 hour	2 -3 hrs	1 hour	4 hrs – 2 days	4 hours
Sonar hours, sonobuoys, torpedoes, detonations, targets, devices, or rounds per year	AQS-22 = 192 dips SSQ-62 (DICASS) = 266 buoys	SQS-53 =578 hrs SQS-56 = 52 hrs MK-39 EMATT = 12 hrs	BQQ-10 = 48 hrs BQS-15 = 24 hrs SUS MK-84 = 24 devices	SSQ-110 = 40 buoys SSQ-125 = 40 buoys	S-A Standard Missile.Sea Sparrow, or RAM=6 A-A AIM-7=18 AIM-9=24 AIM-120=18	5" (Inert) = 48 5" (HE) = 84 76mm (Inert)=16 76mm (HE)=28 57mm (Inert)=200 25mm (Inert)=6,000 20mm (Inert)=20,000 7.62mm (inert)=9,000 .50 cal (inert)=2,400	BDU-45 (inert) = 216 MK-82 (HE) = 128 MK-83 (HE) = 12 MK-84 (lHE) = 4	MK-82 (Inert) =3 MK-82 (HE)=7 MK-83 (HE=4) AGM-88 HARM = 2 AGM-84 Harpoon=5 AGM-65 Maverick=3, AGM-114 Hellfire = 1 AGM-119 Penguin = 1, Standard Missile 1 = 1 Standard Missile 2=1 5"/54 BLP = 500 rounds MK-48=2	MK-84 Pingers = 80 hrs Transponders = 80 hrs
Number of events per Year	44	3	3	4	6	32	36	2	20
Area Used	TMAA	TMAA	TMAA	TMAA	TMAA	TMAA	TMAA	TMAA	
Months of Year conducted	April-October	April-October	April-October	April-October	April-October	April-October	April-October	April-October	April-October

Notes:
For ASW TRACKEX: 53 and 56 number equates to annual hours of use; buoys number equates to annual number of sonobuoys used; MK48 number equates to annual number of MK48 torpedoes used.
mm = millimeter, HE = High Explosive, Inert = Nonexplosive

2 DURATION AND LOCATION

The proposed training events would be conducted within a 21-day exercise period, twice a year, in the Gulf of Alaska (GOA) Temporary Maritime Activities Area (TMAA). These exercise periods would occur only in the summer timeframe between May and October. This Letter of Authorization (LOA) request is only for those Navy training activities at-sea which would occur in the TMAA.

2.1 LOCATION AND DESCRIPTION OF THE GOA TMAA

The GOA forms a large, semicircular bight opening southward into the North Pacific Ocean. The region is bounded by the mountainous coast of Alaska to the west, north, and east and encompasses watersheds of the Alaskan Peninsula from 176º W to the Canadian mainland on Queen Charlotte Sound (127.5º W). The Gulf is characterized by a broad and deep continental shelf containing numerous troughs and ridges, and the region receives high amounts of freshwater input, experiences numerous storms, and undergoes intense variability in waters overlying the continental shelf. (DoN 2006)

Within the northeastern GOA, the TMAA is comprised of the 42,146 square nautical mile (nm^2; 145,482 square kilometer [km^2]) of surface and subsurface area. The TMAA is roughly rectangular, and oriented from northwest to southeast, approximately 300 nautical miles (nm; 556 kilometer [km) long by 150 nm (278 km) wide, situated south of Prince William Sound and east of Kodiak Island. The northern corner of the TMAA is located just over 12 nm (22 km) from Cape Cleare on Montague Island. Other than that location, the nearest shoreline (Kenai Peninsula) is located approximately 24 nm (44 km) from the northeast boundary of the TMAA.

2.1.1 Physiography and Bathymetry

The bathymetry of the GOA reflects the diverse and complex processes that have affected the region during the past few million years. The shelf topography in the northern GOA is extremely complex due to the tectonic and glacial processes that affect this region. Glacial ice extended to the shelf break at least once during the Pleistocene Era, covering the majority of the shelf with a sheet of ice that sculpted broad flat banks and deep troughs from the surrounding terrain. Numerous troughs and canyons, many of which transect the continental shelf, are readily visible along the shelf seafloor. Submarine banks and ridges are also common in the region and are a result of subsidence, uplift, and glacial moraines (deposits of rock debris transported by a glacier). These geological processes have also impacted the formation of the complicated coastline that includes fjords, embayments, capes, and island groupings. (DoN 2006)

The abyssal plain in the GOA gradually shoals from a 16,400 feet (ft; 5,000 meter [m]) depth in the southwestern GOA to less than 9,843 ft (3,000 m) in the northeastern expanses of the Gulf. Maximal depths exceed 22,965 ft (7,000 m) near the central Aleutian Trench along the continental slope south of the Aleutian Islands. Numerous seamounts, remnants of submarine volcanoes, are scattered across the central basin. Several of the seamounts rise to within a few hundred meters of the sea surface. (DoN 2006)

2.1.2 Physical Oceanography

2.1.2.1 Water Masses, Currents, and Circulation

The ocean circulation in the GOA is defined by the cyclonic motion of the Pacific subpolar gyre (also referred to as the Alaska Gyre) which is composed of the North Pacific Current, the Alaska Current, and the Alaskan Stream. Circulation patterns along the shelf divide the region into the inner shelf (or Alaska Coastal Current domain), the mid-shelf, and the outer shelf including the shelf break. (DoN 2006)

The center of the gyre is located at approximately 52 to 53ºN and 145 to 155ºW. Nearshore flow is dominated by the Alaskan Coastal Current and is less organized than the flow found along the shelf break and slope. The northwestern GOA also includes several prominent geological features that influence the regional oceanography. For example, Kayak Island extends 50 km across the continental shelf to the east of the Copper River. This island can deflect shelf waters farther offshore delivering high concentrations of suspended sediment to the outer shelf. (DoN 2006)

During winter months, intense circulation over the GOA produces easterly coastal winds and downwelling, both of which result in a well-mixed water column. During the summer, stratification develops due to decreased winds, increased freshwater discharge, and increased solar radiation. Under summer and fall conditions, the shelf waters are stratified with the upper water column temperatures at their maximum and salinities at their minimum. On longer time scales, there is evidence of interannual variation in the circulation patterns within the GOA. These variations result from the climatic variability of the El Niño Southern Oscillation (ENSO) and the Pacific Decadal Oscillation (PDO). (DoN 2006)

North Pacific Current. The North Pacific Current (NPC), also referred to as the West Wind Drift, flows along the southern boundary of the GOA at a rate ranging from 5 to 15 centimeters per second (cm/sec). The NPC is a trans-Pacific current originating at the confluence of the northward-flowing Kuroshio Current and the southward-flowing Oyashio Current in the western Pacific. The NPC bifurcates off of the western coast of North America; the northward flow feeds into the Alaska Current and constitutes the eastern limb of the Alaskan Gyre, and the southward branch enters the California Current. Along the Aleutian Islands, some water from the Alaskan Stream recirculates into the North Pacific Current; however, the strength and location of this recirculation is poorly understood and extremely variable. (DoN 2006)

Alaska Current. The ocean circulation of the GOA is dominated by a cyclonic boundary current, the Alaska Current; the Alaska Current forms the northern leg of the Alaskan Gyre and is formed by the bifurcation of the NPC. The Alaska Current is broad (54 to 216 nm [100 to 400 km]), highly variable, and forms the dominant transport system of surface waters in the Gulf. It flows adjacent to the coast of North America and sweeps poleward, offshore of the continental shelf, at velocities between 30 and 100 cm/sec. (DoN 2006)

The Alaska Current is rich in eddies and meanders and supports an energetic open ocean mesoscale circulation. At the head of the GOA, the current follows the curve of the shoreline and forms the Alaskan Stream. Shifts in regional climate can also play a role in the transport of the Alaskan Current. During an El Niño event, the Alaskan current destabilizes, creating a higher level of variability in flow volume and direction. (DoN 2006)

Alaskan Coastal Current. The Alaskan Coastal Current is the most prominent aspect of shelf circulation in the GOA. Hugging the inner third of the continental shelf (typically within 19 nm [35 km] of the shore), the Alaskan Coastal Current provides a sizeable and ecologically important transition zone between the nearshore and oceanic communities. The Alaska Coastal Current is a persistent circulation feature that flows to the west throughout the year. This current originates along the shelf of British Columbia; however, in some years the current may start as far south as the Columbia River. (DoN 2006)

The Alaskan Coastal Current is narrow (22 nm [<40 km]) and acts as a "river in the sea"; it is fed by winds, runoff from glaciers, snowmelt, rainfall, and freshwater discharge. Freshwater output is about one-and-a-half times the discharge of the Mississippi River. The width, speed and depth of the Alaskan Coastal Current vary with location along the coast. Maximum transport occurs in the late fall and early winter due to accumulated freshwater discharge and strong winds. Minimum transport occurs in the early summer prior to the spring melt when local wind stress is weak. (DoN 2006)

Alaskan Stream. The Alaskan Stream is the extension of the Alaska Current. Whereas the Alaska Current is a broad, slow flowing current, the Alaskan Stream is a narrow (100 km [62 mi]) and swift (45 to 123 cm/sec) affecting the upper 500 m (1,640 ft) of the water column. The Alaskan Stream flows westward along the Alaska Peninsula and Aleutian Islands, forming the northern (westward) boundary current of the North Pacific Subarctic Gyre (NPSG). The current weakens west of 180ºW. The Alaskan Stream has a mean annual volume transport of 25 to 27.5 x 106 cubic meter per second (m^3/sec), and although seasonal transport variations appear small, interannual transport variations may be as great as 30 percent. (DoN 2006)

Strengthening of the Aleutian Low results in increased velocities of the Alaskan Stream northeast of Kodiak Island and a decrease in velocity southwest of the island. The strengthening is so intense in the northwest GOA that an inertial recirculation occurs southeastward of the Alaskan Stream. (DoN 2006)

Kenai Current. From about 145ºW to Shelikof Strait, a distinct, narrow coastal flow exists throughout the year. This current, the Kenai Current, is usually located within 30 km (19 mi) of the coastline and is present throughout the year, but transport and current velocity increases markedly in the fall months when freshwater runoff is at its peak (DoN 2006). The only exception is near Yakutat, where highest velocities tend to occur in the winter. During most of the year, transport values of 3 x 105 m^3/sec and speeds approach 25 cm/sec are typical; in October, transports exceed 10 x 105 m^3/sec and speeds exceeding 100 cm/sec are common. (DoN 2006)

Eddies

The ocean circulation in the interior of the GOA is influenced by eddies. Large eddies with anticyclonic motion are abundant in this region, and have been implicated as an important mechanism for cross-shelf exchange in the GOA. It has been estimated that during summer months, mesoscale eddies cover an area between 20,000 and 60,000 km^2 (7,722 to 23,166 mi^2) in the GOA. These eddies can influence the cross-shelf transport in two ways: by entraining and trapping shelf water in their interior and the subsequent transport off of the shelf, and by interacting with the nearshore circulation resulting in cross-shelf transport. Eddies formed in this region are typically long-lived and may have lifespans of more than one year. (DoN 2006)

Three major groupings of eddies have been identified in the GOA (Haida, Sitka, and Yakutat eddies) and are primarily distinguished by their formation region. These groups share many common features, including anticyclonic rotation, ~108 nm [200 km] diameters, formation along the eastern boundary, and westward propagation across the GOA. (DoN 2006)

2.1.2.2 Sea Surface Temperature (SST)

Generally, two surface temperature regimes characterize the northern expanses of the GOA throughout the year. Relatively warm surface water occurs over the continental shelf, while colder water is found farther offshore beyond the shelf break. On the inner shelf the mean monthly SSTs range from approximately 3.5 degrees Celsius (°C; 38.3 degrees Fahrenheit [°F]) in March to 14°C (57°F) in August. The average SST for the GOA is reported to be approximately 9.6°C (49.3°F) and has undergone a warming trend since 1957 (Aquarone and Adams 2008). The overall difference in annual temperature diminishes with depth, with the annual range being only 1°C (34°F) at deeper than 150 m (492 ft). Across the shelf changes in SST are generally small (approximately 2°C [36°F]). Surface temperatures within the Alaska Current vary by approximately 10°C (50°F) throughout the year. Temperatures within the coastal inlets (e.g., Cook Inlet) also fluctuate with the tidal cycle; SST decreases during the flood tide as colder shelf and basin water enter the coastal embayments. (DoN 2006)

Interannual variability in cloud cover, especially in summer, can affect SST in the region. Anomalously warm surface waters were observed in the summer and fall of 1997 and were likely due to the unusually low cloud cover and mild winds. The characteristic cloud cover is so heavy during a typical year that the effective use of passive microwave sensors, such as Advanced Very High Resolution Radiometer and Sea-viewing Wide Field of view Sensor (SeaWiFS), are hindered. (DoN 2006)

Warmer SST anomalies are often associated with El Niño events in the GOA. The 1997 event resulted in local SSTs nearly three standard deviations higher than the average. However, the onset of El Niño events do not always result in an immediate shift in SST in the North Pacific Ocean; SST anomalies were detected in the region one year following the onset of the 1976, 1982, 1986, and 1992 ENSO events. During positive PDOs, the GOA experiences above-average SSTs while the central and western Pacific Ocean undergoes below-normal surface temperatures. Opposite SST regimes dominate during negative PDOs. Following the 1977 regime shift to the warm PDO state, summer SSTs increased by 0.6ºC. (DoN 2006)

El Niño and La Niña

The ENSO events results from interannual changes in sea level pressures between the eastern and western hemispheres of the tropical Pacific. These events can initiate large shifts in global climate, atmospheric circulation, and oceanographic processes. El Niño conditions typically last 6 to 18 months although they can persist for longer periods of time; they are the main signs of global change over time scales of months to years. (DoN 2006)

El Niño conditions occur when unusually high atmospheric pressure develops over the equatorial Pacific and Indian Oceans and low sea level pressures develop in the southeastern Pacific. The trade winds weaken in the central and west Pacific; thus, the normal east to west surface water transport and upwelling along South America decreases. This causes the SST to increase across the mid to eastern Pacific. In the western equatorial Pacific, SST decreases and rainfall patterns shift eastward across the Pacific resulting in increased (sometimes extreme) rainfall across the southern U.S. and Peru and drought conditions in the western Pacific. Historically, strong El Niño events have been documented in 1940, 1958, 1983, 1992, and 1997 to 1998. (DoN 2006)

La Niña is the opposite phase of El Niño in the Southern Oscillation cycle. La Niña is characterized by strong trade winds that push the warm surface waters back across to the western Pacific. Under these conditions and due to increased upwelling along the eastern Pacific coastline, the thermocline in the western Pacific deepens and the thermocline in the eastern Pacific becomes shallower. Often with La Niña, the climatic effects are the opposite of those encountered during an El Niño warming event. On 3-year to 7-year time scales, ENSO can be an important influence on the GOA, although to a lesser extent than the PDO. El Niño events in this region are typically accompanied by positive anomalies in wintertime air temperature, precipitation, along-shore wind (i.e., downwelling favorable), and sea level. La Niña events in the region tend to include negative anomalies. El Niño events have affected the GOA in 1977, 1987, and 1998 which featured warmer, wetter winters in the northern regions. The El Niño of 1998 was followed by an equally strong La Niña event in 1999. (DoN 2006)

Pacific Decadal Oscillation (PDO)

The PDO, the leading mode of variability in the North Pacific, is a long-term climatic pattern capable of altering the SST, surface winds, and sea level pressure. The PDO is often described as a long-lived El Niño-like pattern of Pacific climate variability with both warm (positive) and cool (negative) phases. However, the PDO possesses three characteristics that distinguish it from ENSO events and El Niño. First, PDO events can persist for 20 to 30 years, in contrast to the relatively short duration of the ENSO (typically up to 18 months). Second, climatic effects of the PDO are more prominent in ecosystems outside the tropics. Third, the mechanisms controlling the PDO are unknown, while those forces creating ENSO variability have been well resolved. (DoN 2006)

Every 20 to 30 years, the surface waters of the central and northern Pacific Ocean shift several degrees from the mean. These shifts in the mean surface temperatures have occurred five times in the last century and are linked to the 10 to 20 year variability of the Aleutian Low Pressure System. The location and intensity of the Aleutian Low is not constant. When the low is intense, local weather is stormy with increased precipitation in the coastal mountains along with and elevated sea levels and warmer water temperatures in the eastern GOA. Under these conditions, the positive phase of the PDO, wind induced cross-shelf transport increases, as does flow in the Alaska Coastal Current. During the opposite phase of the PDO, cooler seas prevail in the region. Positive PDOs dominated the GOA region from 1925 to 1946 and from 1977 to about 1999. Negative PDOs occurred from 1890 to 1924, 1947 to 1976, and 1999 to present. (DoN 2006)

2.1.2.3 Thermocline

The thermocline is located between the surface and deepwater circulation zones; it is a transition region where water temperatures change rapidly from warmer surface waters to colder deep waters. In the GOA, the inner shelf and Prince William Sound stratify first, and the stratification of the water column gradually spreads offshore through ocean processes. Solar heating provides additional surface buoyancy by warming the upper layers uniformly across the shelf. Thermal stratification remains weak until late May or June, then strong stratification persists through the summer months. As winds intensify in the fall, stratification dissipates, due to stronger vertical mixing and increased downwelling, surface waters sink along the coast, and the thermocline deepens throughout the region. Along the continental shelf and within the coastal fjords, waters are often highly stratified by both salinity and temperature; an intense thermocline occurs at approximately 82 ft (25 m). Farther offshore in the Alaskan Stream, maximal stratification occurs between depths of 328 ft to 984 ft (100 to 300 m) and is associated primarily with a permanent halocline in the GOA. (DoN 2006)

2.1.2.4 Salinity

The entire North Pacific is less saline than the North Atlantic due to complex and poorly understood processes. In contrast to the more saline North Atlantic, the presence of fresh water in the North Pacific has inhibited the development of deep water masses, with important consequences for oceanic heat transport. On an annual average the freshwater influx is enormous (approximately 23,000 m^3/sec); this discharge, approximately 20 percent greater than the mean annual Mississippi River discharge, accounts for nearly 40 percent of the freshwater flux into the GOA. This runoff enters the shelf mainly through many small drainage systems, rather than from several large rivers. The discharge reaches a maximum in the early fall and decreases rapidly through winter, when precipitation is stored as snow. (DoN 2006)

2.1.3 Biological Oceanography

2.1.3.1 Plankton

Plankton are organisms that float or drift in the water column and are unable to maintain their position against the movement of water masses; they are at the mercy of the currents in the local aquatic environment. Planktonic assemblages include bacterioplankton (bacteria), zooplankton (animals) including ichthyoplankton (larval fish), and phytoplankton (plant-like). In general, plankton are very small or microscopic although there are exceptions. For example, jellyfish and pelagic Sargassum are considered part of the plankton group due to their inability to move against surrounding currents even though some jellyfish can grow to 3 m (10 ft) in diameter. (DoN 2006)

2.1.3.2 Primary Production and Photosynthesis

Primary production is a rate at which the biomass of organisms change and is defined as the amount of carbon fixed by organisms in a fixed volume of water through the synthesis of organic matter using energy derived from solar radiation or chemical reactions. The major process through which primary production occurs is photosynthesis. The intensity and quality of light, the availability of nutrients, and seawater temperature all influence primary productivity as generated through photosynthesis. (DoN 2006)

The GOA is one of the world's most productive ocean regions. Primary production in the GOA OPAREA and vicinity has been estimated at 100 to 170 grams of carbon per square meter per year. Closer inshore, annual rates can approach 200 to 300 grams of carbon per square meter per year. (DoN 2006)

2.1.3.3 Phytoplankton

Phytoplankton photosynthesize to convert light energy into chemical energy; thereby, in the oceans, they comprise the lowest level of the food web and can be considered the most important group of organisms in the ocean. A vast majority of organisms in the oceans depend either directly or indirectly on phytoplankton for survival. Growth and distribution of phytoplankton are influenced by several factors including temperature, light, nutrient concentration, pH, and salinity. In general, the distribution of phytoplankton is patchy, occurring in regions with the optimal conditions for growth. The concentration of chlorophyll measured in the water column or at the sea surface can be used as a proxy for phytoplankton; regions of enhanced chlorophyll concentrations are indicative of high phytoplankton abundance. In general, the concentration of phytoplankton (chl a) decreases with increased distance from the shore and water depth. (DoN 2006)

2.1.3.4 Continental shelf and Nearshore Waters

Although the predominance of downwelling conditions in the GOA limits the supply of nutrients to the shelf, it remains a highly productive region. Frequent storms, high tidal energy, persistent storms, and localized upwelling appear to be the primary mechanisms that enhance vertical mixing along the coastal shelf. Shelf and coastal waters host a traditional phytoplankton community composed of nanoplankton and microplankton; large and small diatoms and dinoflagellates tend to dominate the region. When production is high, diatoms commonly account for more than 80 percent of the phytoplankton. (DoN 2006)

In the GOA, the annual production cycle is characterized by well-defined spring (and sometimes fall) blooms of large diatom species (most are larger than 50 µm). These blooms typically begin in late March and early April in response to a seasonal stabilization of the winter-conditioned deep mixed layer, and increased ambient light. (DoN 2006)

High rates of photosynthesis typically last only 4 to 6 weeks before being controlled by nutrient depletion, sinking, and zooplankton grazing. The timing, duration, and intensity of blooms are controlled largely by the physical structure of the water column. (DoN 2006)

In the late spring and early summer, large diatom-dominated spring blooms decline as nutrient supplies are diminished; dinoflagellates and other smaller forms are the dominant taxa under these conditions. In Prince William Sound, dominance in the phytoplankton bloom was shared by the large chain-forming diatoms including Skeletonema, Thalassiosira, and Chaetoceros. Later in June, when nutrients become more restrictive to growth, phytoplankton are dominated by smaller diatoms (e.g., Rhizosolenia) and tiny flagellates. Regions southeast of Kodiak Island have higher standing stocks during the summer than shelf regions to the northeast where fewer submarine canyons and troughs are located. (DoN 2006)

2.1.3.5 Zooplankton

Shelf waters in the GOA host a traditional plankton community in which large phytoplankton (diatoms and dinoflagellates) are grazed upon by copepods. The dominant zooplankters that inhabit the GOA are copepods and cnidarians, and abundance and species composition is largely driven by local salinity. In addition to copepods, larger micronektonic species (e.g., euaphausiids, amphipods, and some shrimp species) can be important zooplankton components in the diets of local fish and large predators. Highest levels of biomass tend to occur in the summer months of May (copepods) and August (cnidarians); lowest values tend to occur in February. Cross-shelf distribution of zooplankton is influenced by their depth preferences, migration behavior, salinity and temperature preferences, and water movement. A mid-shelf transition region also can be identified where the zooplankton community is composed of a mixture of neritic and oceanic species. (DoN 2006)

Grazing by the larger mesozooplankton (i.e., copepods) accounts for only a small percentage of phytoplankton mortality in the Alaska Gyre. Rather, production of phytoplankton in the oceanic regions of the GOA is thought to be controlled by an assemblage of microzooplankters and microconsumers, represented by abundant ciliate protozoans and small flagellates, rather than by large copepods. Because the growth rates of these grazers are higher than those of the phytoplankton, it is hypothesized that these consumers are capable of efficiently tracking and limiting the overall oceanic productivity by eating the primary producers. Oceanic zooplankton in the upper layers of the water column exhibit marked seasonality. In the late winter, biomass of zooplankton in the region increased five to one-hundred fold (values increase from 5 to 20 milligram per cubic meter [mg/m^3] in the winter to 100 to 500 mg/m^3 in the mid-summer). During this increase, copepods dominate the zooplankton community. (DoN 2006)

Many of the zooplankton inhabiting the GOA migrate diurnally over 100 m (328 ft) or more. These migrations may interact with vertical or horizontal currents in ways that create localized swarms and patches of plankton in the region. (DoN 2006)

El Niño events have little effect on the phytoplankton composition within the shelf waters of the GOA. Horizontal expansion of zooplankton stocks occurs during warm periods of the PDO along the coast. Both El Niño and the PDO affect the phytoplankton assemblage in the oceanic regions. Following the shift to a positive (warm) PDO regime in the late 1970s, zooplankton biomass doubled in the offshore regions of the GOA. During an El Niño event, a shallower mixed layer restricts the supply of nutrients to the ocean surface. In turn, the entire GOA experiences extreme nitrate depletion and decreased levels of primary production. Zooplankton become depleted as their food source is not in as abundant of supply. (DoN 2006)

2.1.3.6 Habitat

The GOA region has four representative habitat types: watersheds, intertidal and subtidal area, Alaska Coastal Current, and offshore areas (Mundy and Spies 2005). The TMAA is at least 12 nm (22 km) off Montague Island and 24 nm (44 km) off the Kenai Peninsula and includes primarily offshore habitats including continental shelf, slope, and abyssal plain regions, which are influenced by both the Alaska Coastal Current and the Alaska Gyre. The habitats associated with these cold and turbulent waters contain identifiable collections of macrohabitats that sustain resident and migratory species including seabirds, marine mammals, invertebrates, and fishes (e.g., salmon and groundfish; Mundy and Cooney 2005, Mundy and Spies 2005); these habitats support some of the largest fisheries in the United States. Aquarone and Adams (2008) report the total reported landings from the fisheries in the GOA is on the order of 600 to 700 thousand tonnes (approximately 700 to 800 tons) annually.

2.1.3.7 Benthos

The variety of bottom substrates and the complicated system of water circulation and bathymetry in the GOA results in a complex benthos. The distribution of the benthos in the GOA is primarily a function of depth (i.e., light penetration, temperature, and wave action) and substrate (i.e., availability and type of substrate and movement and accumulation of sediments). (DoN 2006)

In addition, the distribution, diversity, and abundance of the benthos of the GOA are strongly influenced by the Alaska Coastal Current in conjunction with heavy sediment loads that originate from glacial meltwater. The GOA has a relatively wide shelf (up to 100 km [62 mi]) with several banks bisected by submarine canyons. Most regions of the GOA shelf experience high sedimentation rates of clayey silt that results in poorly consolidated sediments; however, in some relatively shallow areas, few sediments accumulate because of scouring by strong bottom currents and frequent winter storm waves. The megahabitats of the TMAA include the continental shelf (<200 m [<656 ft]), upper slope (~200 to 3,000 m [656 to 9,842 ft]), submarine canyons (200 to 400 m [656 to 1,312 ft]), and abyssal plain (~3,000 to 5,000 m [9,842 to 16,404 ft]). Over 400 infaunal invertebrate taxa, representing 11 phyla, and approximately 180 epifaunal species, representing ten phyla, have been described along the continental shelf. Over the entire shelf of the GOA, the mean diversity and species richness was highest on banks and at the shelf break. (DoN 2006)

2.1.3.8 Continental Shelf

Much of the continental shelf is covered with sand, mud, silt, bits of broken shell, and other fine materials that are often inhabited by organisms living within the upper layers of the seafloor (infauna) or on the surface of these seafloor substrates (epifauna). The benthic invertebrate fauna of the GOA differs markedly as a function of bottom type. Epifauna live attached to or rove over the sediment surface wherever suitable substrate occurs. For example, sponges, barnacles, anthozoans, soft corals, ascidians, sea whips, sea pens, mussels, and bryozoans are distributed throughout the continental shelf of the GOA, many of which provide important structure to the soft sediment seafloor. Infaunal invertebrates such as polychaetes, clams, nematodes, and amphipods burrow into sand and mud bottoms and stabilize the sediments. These benthic invertebrates serve as prey for mobile epibenthic invertebrates and for demersal fishes. In the GOA, common predatory invertebrates include sea stars (e.g., leather and sunflower star), crabs (e.g., helmet, Dungeness, king, snow, and Tanner crabs) shrimp (Carangon and Pandalus shrimps), gastropods, and some scavenging invertebrates. (DoN 2006)

The shelf of the TMAA is a complex and dynamic geologic environment characterized by banks, patchy rocky substrate, and patchy bottom sediments. Banks are exposed to both wave and current action (particularly during winter storms) that continually resuspend bottom sediments. In the GOA at the western edge of the TMAA, the benthos of Portlock Bank was surveyed from about 50 to 750 m (164 to 2,461 ft). The seafloor is generally flat and covered with small boulders, cobble, and gravel. The most common epifauna were crinoids, small non-burrowing sea anemones, glass sponges, stylasterid corals, and brittlestars. (DoN 2006)

2.1.3.9 Continental Slope

Bottom substrate type governs the abundance and diversity of deep-sea organisms. Abundance and diversity are generally higher on hard, irregular substrates than on smooth, hard surfaces (Lissner, 1988). Therefore, the outer continental shelf and the continental slope are not well studied in the GOA system. There has been some description of the mobile epibenthic communities and the demersal fish communities; however, most sampling of the continental slope habitats involves trawling and focuses on the commercial fisheries of crabs, shrimps, and demersal fishes. The continental shelf represents key fishing ground in the GOA and has correspondingly high value to humans. (DoN 2006)

As previously noted, Slope Habitat Conservation Areas have been designated and two of these (Cable and Middleton West) are located within the TMAA (Figure 1-2).

2.1.3.10 Submarine Canyon Communities

The GOA continental shelf and slope is highly dissected by numerous submarine canyons. Submarine canyons contain various habitats, including vertical cliffs, ledges, talus, cobble and boulder fields, and soft mud. Generally, rocky substrate lines steep canyon walls; whereas, the bottom of the canyon is formed of a gently sloping bottom that accumulates sediments to form the soft substrate (e.g., silt and mud). The organisms that live in submarine canyon habitats must be able to withstand extreme conditions; with depths in excess of 500 m (1,640 ft), little or no light, cold water temperature, and tremendous pressure (up to 318 atmospheres). (DoN 2006)

Some of the production associated with submarine canyons is introduced via adjacent habitats. Drift macroalgae and other organic matter produced in shallow or surface waters may settle and accumulate at the mouth and along the slopes of submarine canyons. This detritus may be washed down into the canyon during storms, contributing to productivity in the deep sea. In addition, the soft substrate at the base of the canyons supports a diverse invertebrate community. The complex structure of rocky substrate in submarine canyons provide cover for numerous fish species (e.g., groundfish) and can help to protect these species from over-fishing because they tend to be difficult to locate and target. However, submarine canyons are vulnerable to human activities; they extend across a range of depths and may be heavily influenced by the deposition of sediments and pollutants that is associated with coastal development. (DoN 2006)

2.1.3.11 Seamounts

Seamounts are isolated undersea mountains rising from 900 to 3,000 m (2,953 to 9,842 ft) above the surrounding bottom. Seamounts are found in all oceans but are more numerous in the Pacific Ocean, with over 2,000 having been identified (Thompson et al., 1993). Seamounts are capable of supporting a wide range of organisms, a wide array of sponges, coral, brittlestars, crinoids, clams, seastars, polychaetes, crabs, tunicates, sea urchins, sea cucumbers, and octopi. Seamounts attract various predators, including fishes and marine mammals as a result of this relatively high biomass. (DoN 2006)

A rich and diverse benthic fauna with a high degree of endemism exists on seamounts. In one study, levels of endemism among 850 macro- and megafaunal species (including fish) were as high as 29 to 34 percent. Thus, seamounts can function ecologically as island groups or chains, leading to localized species distributions with apparent speciation. Dispersal of organisms from the seamounts is likely an active and a passive process; seamounts appear to provide “stepping stones” for trans-oceanic dispersal of animals in both the Atlantic and Pacific. Few studies have investigated the interaction between seamount inhabiting organisms and the surrounding abyssal plain, nearshore area, and other seamounts habitats. (DoN 2006)

The global status of seamount benthic communities is unknown; however, the limited distribution of seamount biota greatly increases the threat of extinction. The conservation and protection of seamount communities is necessary and requires action to be taken on a local scale. Lingcod spawn in very deep water at the base of pinnacles and seamounts and giant spider crabs have been discovered that span over seven feet across. Some pinnacles, such as the Albatross Pinnacle south of Kodiak Island, come close to the surface and provide a substrate for kelp that in turn provide essential rearing habitat for juvenile fish. These pinnacles are known to be covered with sponges, anemones, hydroids, tunicates, barnacles, crabs, worms, snails, chitons, and other invertebrates and algae. (DoN 2006)

As noted previously, four Seamount Habitat Protection Areas are located in the TMAA (three partially): (1) Dall, (2) Kodiak, (3) Giacomini, and (4) Quinn (Figure 1-2).

3 MARINE MAMMALS

The Gulf of Alaska (GOA) area is a productive environment and there is a rich marine mammal fauna, as evidenced in abundance and species diversity (Leatherwood et al., 1988; Bonnell and Dailey, 1993). In addition to many marine mammal species that live here year-round and use the region's waters for foraging, breeding, and islands for hauling out, there is a community of seasonal residents and migrants. These species include, for example, the humpback whale (*Megaptera noveangliae*) and gray whale (*Eschrichtius robustus*), which both feed in Alaska waters in roughly the May to September timeframe.

As shown in Table 3-1 (presented later in this section), There are 27 species of marine mammals with possible or confirmed occurrence in the waters of the GOA (Carretta et al. 2007, Angliss and Allen 2008, Rone et al. 2009, Stafford 2009), but not all inhabit waters within the TMAA. These consist of 20 cetacean species, populations, or stocks (seven species of baleen whales [mysticetes] and 13 toothed whales, dolphins, and porpoises [odontocetes]), five pinnipeds (sea lions, fur seals and true seals), and one sea otter species.

Table 3-1 summarizes the abundance, Endangered Species Act (ESA) status, Marine Mammal Protection Act (MMPA) status, population trends for the GOA, and the likelihood of occurrence and derived density for these species in the Temporary Maritime Activities Area (TMAA). For the TMAA, most of these species are listed as "common" in Table 3-1, indicating that they occur routinely, either year-round or during annual migrations into or through the area. The other species listed as "rare" have sporadic sightings and species listed as "very rare" are very few in number and are unlikely to be encountered in the TMAA during Navy training activities. Those species considered "extralimital" are considered outside their normal habitat range in the TMAA although record of a previous sighting or stranding may have been documented on a few occasions in GOA. All of the species that occur in the TMAA are either cosmopolitan (occur worldwide), or associated with the temperate and sub-Arctic oceans (Leatherwood et al. 1988).

3.1 SPECIES SUMMARIES AND LIFE HISTORY FOR THE TMAA

Temperate and warm-water toothed whales often change their distribution and abundance as oceanographic conditions vary both seasonally (Forney and Barlow, 1998) and interannually (Forney 2000). Forney and Barlow (1998) noted significant north/south shifts in distribution for Dall's porpoises, common dolphins, and Pacific white-sided dolphins, and they identified significant inshore/offshore differences for northern right whale dolphins and humpback whales. Several authors have noted the impact of the El Niño events of 1982/1983 and 1997/1998 on marine mammal occurrence patterns and population dynamics in the waters off California (Wells et al. 1990, Forney and Barlow 1998; Benson et al. 2002), which are assumed in the analysis for this LOA request to affect distribution in Alaskan waters as well.

Water temperatures in the TMAA, even in the summer, have an impact on the distribution of marine mammals that may otherwise be present in other areas of the North Pacific. As detailed in Section 3.4.4, the following marine mammal species are not expected to be present in, are considered extralimital to, the TMAA given their documented habitat preferences for warmer waters (DoN 2006, Angliss and Outlaw 2007): false killer whale (*Pseudorca crassidens*), Northern right whale dolphin (*Lissodelphis borealis*), Risso's dolphin (*Grampus griseus*), and short-finned pilot whale (*Globicephala macrorhynchus*). The National Marine Fisheries Service (NMFS) Stock Assessment Report does not include these species as marine mammals present in Alaska waters (Angliss and Allen 2008).

In addition, the waters of the TMAA are offshore of the habitat for sea otter (*Enhydra lutris*), Cook Inlet beluga whale (*Delphinapterus leucas*), and harbor seal (*Phoca vitulina*) (Kenyon 1981, Baird 2001, National Oceanic and Atmospheric Administration 2008). Since the TMAA is 12 to 24 nautical miles (nm; 22 to 24 kilometers [km]) from the nearest shoreline and well beyond the normal range of these species, they will be discussed briefly (Section 3.4.4) and then dismissed from further analysis.

3.2 DATA SOURCES

The *Marine Resources Assessment for the Gulf of Alaska* (DoN 2006) was used as a baseline for describing the physical, biological, marine, terrestrial, and cultural features particular to this region. These descriptions are presented in Section 4. For some species, the TMAA may constitute a large portion of their total range. Other species, such as baleen whales, may only be there seasonally to feed. Other data resource included a detailed search of multiple peer-review scientific journals, and government reports. Several search engines were used in this process including Science Direct®, High Wire Press®, Directory of Open Access Journals, the Journal of the Acoustical Society of America-Online (JASA-O). Science Direct® databases provide access to more than 8 million articles in over 2,000 journals focused on the physical sciences and engineering, life sciences, health sciences, and social sciences and humanities. High Wire Press® offers access to nearly 4.3 million articles published by approximately 1,040 journals. Topics for journals in these databases include biological, social, medical, and physical sciences and the humanities. The Directory of Open Access Journals includes peer-reviewed scientific and scholarly publications that are available to the public free of charge. The searches of each database included general queries in the resource areas of and potential effects to marine species (marine mammals, sea turtles, fish, and birds), socioeconomics (fisheries, tourism, boating, and diving), natural resources (oil and gas), artificial reefs, whale and dolphin watching, and cultural resources. Finally, JASA-O offers search capabilities for and access to articles as early as 1929. Searches for articles available from this journal included focused information on hearing capabilities and potential effects on marine species such as marine mammals, sea turtles, manatees, fish, and diving birds. In addition to search engines and science information portals, a direct review was conducted of other journals that regularly publish marine mammal related articles (e.g., Marine Mammal Science, Canadian Journal of Zoology, Journal of Acoustical Society of America, Journal of Zoology, Aquatic Mammals). References were also obtained from previous environmental documents where applicable, and from mitigation and regional monitoring reports. The original reference authors were contacted directly if necessary to clarify particular points presented in a paper or gain additional insight into the data analysis.

3.3 DATA QUALITY AND AVAILABILITY

Recent advances in marine mammal tagging and tracking have contributed to the growth of biological information including at-sea movements and diving behavior. Given the development of this new technology and difficulties in placing tags on marine mammals in the wild, the body of literature and sample size, while growing, is still relatively small. Additional information was also solicited from acknowledged experts within academic institutions and government agencies such as NOAA Fisheries, Alaska Region.

3.4 SPECIES AND OCCURRENCE

3.4.1 Threatened and Endangered Marine Mammal Species

Stocks of all species listed as endangered under the ESA are automatically considered "depleted" and "strategic" under the MMPA. The specific definition of a strategic stock is complex, but in general it is a stock for which human activities may be having a deleterious effect on the population and may not be sustainable.

In addition to those species listed under the ESA, all marine mammals are protected under the MMPA of 1972, amended 1994, administered by the National Oceanic and Atmospheric Association (NOAA) and the U.S. Fish and Wildlife Service (USFWS). Detailed information for all species is included in Section 4.

3.4.1.1 Cetaceans

Six cetacean species are listed as Endangered under the ESA and can possibly occur within the TMAA. These include the blue whale (*Balaenoptera musculus*), fin whale (*Balaenoptera physalus*), humpback whale (*Megaptera novaeangliae*), North Pacific right whale (*Eubalaena japonica*), sei whale (*Balaenoptera borealis*), and sperm whale (*Physeter macrocephalus*).

3.4.1.2 Pinnipeds

One pinniped species, the western and eastern stocks of the Steller sea lion (*Eumetopias jubatus*), regularly occurs within the TMAA and is listed as Threatened under the ESA. Section 4 includes detailed information for this species.

3.4.2 Non-Threatened and Non-Endangered Cetaceans

3.4.2.1 Baleen Whales

There are two non-ESA listed species of baleen whales with confirmed or likely occurrence in the TMAA. Gray whales were removed from the endangered list in 1994 because of an increase in population numbers (Carretta et al. 2005). The Alaska stock of minke whales is not listed as threatened or endangered under ESA and is not considered a depleted or strategic stock (Angliss and Outlaw 2007).

3.4.2.2 Toothed Whales

There are seven non-ESA listed species of toothed whales with confirmed or likely occurrence in the TMAA (in addition there are four possible populations of killer whales). Dolphin species are the most numerous cetacean species within the TMAA (DoN 2006, Angliss and Outlaw 2007). From Table 3-1, the most common species within TMAA include Dall's porpoise (*Phocoenoides dalli*) and Pacific white-sided dolphin (*Lagenorhynchus obliquidens*). Although harbor porpoise (*Phocoena* phocoena) in the GOA and Southeast Alaska stocks are numerous, the majority of the TMAA is well outside the normal (inshore) preferred range of this species with only a fraction of the northwestern margin of the TMAA extending into the likely range of the GOA stock.

The locationally specific occurrence and abundance of beaked whale species (Ziphiidae) off the coast of Alaska is uncertain given the cryptic behavior of these species and the difficulties of accurate at-sea species-level identification. Beaked whales potentially found within GOA include Baird's beaked whale (*Berardius bairdii*), Cuvier's beaked whale (*Ziphius cavirostris*), and Stejneger's beaked whale (*Mesoplodon. stejnegeri*). Stejneger's beaked whale is probably the most common beaked whale in Alaska waters (DoN 2006); therefore, this analysis uses the abundance and density for Cuvier's beaked whale in the TMAA as surrogate given data for Stejneger's beaked whale is otherwise unavailable.

3.4.3 Non-Threatened and Non-Endangered Seals and Sea Lions

There are four non-ESA listed species of pinnipeds with confirmed or likely occurrence in the TMAA. As presented in Table 3-1, these include the California sea lion (*Zalophus californianus*), harbor seal *(Phoca vitulina richardii),* northern elephant seal (*Mirounga angustirostris*), and the northern fur seal (*Callorhinus ursinus*).

Table 3-1. Summary of Marine Mammal Species Found in the GOA

Common Name ***Species Name***	**Abundance (CV)**	**Stock**	**Calculated Density in the TMAA[a] (animals per km^2)**	**Population Trend**	**Occurrence in the TMAA (Apr - Dec)**	**Designated Critical Habitat**
ESA Listed Cetaceans						
Blue whale[1,3,4] *Balaenoptera musculus*	1,368 (0.22)	Eastern North Pacific	No Density	May be increasing	Very rare	None in North Pacific
Cook Inlet Beluga Whale[1,3,4] *Delphinapterus leucas*	375[b]	Cook Inlet	NA	Decreasing	Extralimital	None
Fin whale [1,3,4] *Balaenoptera physalus*	2,636 (0.15)	Northeast Pacific	0.010	Increasing 4.8 percent annually	Common	None
Humpback whale[1,3,4] *Megaptera novaeangliae*	4,005 (0.95)	Central North Pacific and Western North Pacific	0.0019	May be increasing	Common	None
North Pacific Right Whale[1,3,4] *Eubalaena robustus*	Unknown (may be < 100 whales)	Eastern North Pacific	No Density	Unknown (may be decreasing)	Very rare	Yes- Outside of the TMAA
Sei whale[1,3,4] *Balaenoptera borealis*	43 (0.61)	Eastern North Pacific	No Density	May be increasing	Very rare	None
Sperm whale[1,3,4] *Physeter macrocephalus*	Unknown	North Pacific	0.0003	Unknown	Rare	None
ESA Listed Pinnipeds						
Steller sea lion [2,3,4] *Eumetopias jubatus*	45,095-55,832	Eastern U.S.	0.0098	Increasing (3.1 percent/year)	Common	Yes- Outside of the TMAA
Steller sea lion [1,3,4] *Eumetopias jubatus*	38,988	Western U.S.	0.0098	Decreasing (5.4 percent/year)	Common	Yes- Outside of the TMAA

Table 3-1. Summary of Marine Mammal Species Found in the GOA (continued)

Common Name *Species Name*	**Abundance (CV)**	**Stock**	**Calculated Density in the TMAA[a] (animals per km²)**	**Population Trend**	**Occurrence in the TMAA (Apr - Dec)**	**Designated Critical Habitat**
ESA listed Mustelid						
Sea otter *Enhydra lutris*	Unknown	South Central, Southeast and South West Alaska[2,3]	NA	Increasing	Extralimital	None
Non-ESA Listed Cetaceans						
Baird’s beaked whale *Berardius bairdii*	Unknown	Alaska	0.0005	Unknown	Rare	None
Cuvier’s beaked whale *Ziphius cavirostris*	Unknown	Alaska	0.0022	Unknown	Common	None
Dall’s porpoise *Phocoenoides dalli*	83,400 (0.097)	Alaska	0.1892	Unknown	Common	None
False killer whale *Pseudorca crassidens*	Unknown	Hawaii	NA	Unknown	Extralimital	None
Gray whale *Eschrichtius robustus*	18,813 (0.069)	Eastern North Pacific	0.0125	Increasing	Common	None
Harbor porpoise[3] *Phocoena phocoena*	41,854 (0.224)	Gulf of Alaska	No Density	Stable	Rare	None
Killer whale- *Orcinus orca* (Multiple stocks that may occur in the TMAA)	249-1,123	Eastern North Pacific Alaska Resident & Northern Resident, Gulf of Alaska, Aleutian Islands and Bering Sea, AT1[3,4], West Coast and Offshore	0.010 (for all killer whales)	Increasing	Common	None
Minke whale *Balaenoptera acutorostrata*	Unknown	Alaska	0.0006	Unknown	Rare	None
Northern right whale dolphin *Lissodelphis borealis*	12,876 (0.30)	California/ Oregon/ Washington	NA	No trend	Extralimital	None

Table 3-1. Summary of Marine Mammal Species Found in the GOA (continued)

Common Name ***Species Name***	**Abundance (CV)**	**Stock**	**Calculated Density in the TMAA[a] (animals per km²)**	**Population Trend**	**Occurrence in the TMAA (Apr - Dec)**	**Designated Critical Habitat**
Pacific white-sided dolphin *Lagenorhynchus obliguidens*	26,880 (0.90)	North Pacific	0.0208	Unknown	Common	None
Risso's Dolphin *Grampus griseus*	11,621 (0.17)	California, Oregon, and Washington	NA	Unknown	Extralimital	None
Short-finned pilot whale *Globicephala macrorhynchus*	245 (0.97)	California, Oregon, and Washington	NA	Unknown	Extralimital	None
Stejneger's beaked whale *Mesoplodon stejnegeri*	Unknown	Alaska	Density of Cuvier's beaked whale used as a surrogate[c]	Unknown	Common	None
Non-ESA Listed Pinnipeds						
California sea lion *Zalophus californianus*	238,000	U.S.	No Density	Increasing	Very rare	None
Harbor seal *Phoca vitulina richardii*	45,975 (0.04)	Gulf of Alaska	NA	Stable	Very rare	None
Northern elephant seal *Mirounga angustirostris*	124,000	California Breeding	0.0022	Increasing	Common	None
Northern fur seal[3,4] *Callorhinus ursinus*	665,550	Eastern Pacific	0.1180	Increasing	Common	None

Sources: Barlow and Forney 2007, Angliss and Allen 2008, Carretta et al. 2007, DoN 2007, Dahlheim et al. 2009

Notes: ESA notations: [1]endangered; [2]threatened. MMPA designations: [3]strategic stock; [4]depleted.

[a] Densities calculated for summer as discussed in Appendix B

[b] NOAA 2008a; Endangered Status for the Cook Inlet Beluga Whale

[c] No current estimates of abundance for Stejneger's beaked whales are available. Given that sufficient information exists for Cuvier's beaked whale, they are in the same taxonomic family, and the predicted density of Cuvier's beaked whale in the GOA is higher than that of Baird's beaked whales, estimates therefore err on the side of overestimation.

CV = Coefficient of Variation

km² = square kilometer

TMAA = temporary Maritime Activities Area

NA = not applicable given species is extralimital to TMAA.

3.4.4 Marine Mammal Species Excluded from Further Analysis

3.4.4.1 Cook Inlet Beluga Whale (*Delphinapterus leucas*)

Only 28 sightings of beluga in the GOA have been reported from 1936 to 2000 (Laidre et al. 2000). The nearest beluga whales to the TMAA are in Cook Inlet with an abundance estimate of 375 whales in the Cook Inlet stock as of 2008 (NOAA 2008a). Cook Inlet beluga whales were listed as endangered on 22 October 2008 and have been previously designated as depleted under the MMPA (NOAA 2008a). Cook Inlet beluga whales do not leave the waters of Cook Inlet (NOAA 2007a, 2008a). Cook Inlet is approximately 70 nm (129.6 km) from the nearest edge of the TMAA. Based on this information, and the regulatory definition of the stock as those beluga whales confined to the waters of Cook Inlet, this stock of beluga whales will not be present in the TMAA, so this species will not be considered in greater detail in the remainder of this analysis.

3.4.4.2 False Killer Whale (*Pseudorca crassidens*)

False killer whales should not occur in the TMAA. False killer whales are found in tropical and temperate waters, generally between 50°S and 50°N latitude (Baird et al. 1989, Odell and McClune 1999). The southernmost point boundary of the TMAA is well north of 55°N latitude. There have been records of false killer whale sightings as far north as the Aleutian Islands and Prince William Sound in the past (Leatherwood et al. 1988). A solitary false killer whale was sighted in May 2003 near Juneau, but this was considered to be far north of its normal range (DoN 2006). There are no abundance estimates available for this species in the NMFS stock assessment report for this area of the Pacific. In summary, false killer whales are considered extralimital to the TMAA and will not be considered further in this analysis.

3.4.4.3 Northern Right Whale Dolphin (*Lissodelphis borealis*)

Northern right whale dolphins (*Lissodelphis borealis*) should not occur in the TMAA. This species occurs in North Pacific oceanic waters and along the outer continental shelf and slope in cool temperate waters colder than 20°C. This species is distributed approximately from 30°N to 55°N and 145°W to 118°E (both south and east of the TMAA). There are two records of northern right whale dolphins in the GOA (one just south of Kodiak Island), but these are considered extremely rare (DoN 2006). There are no abundance estimates available for this species in the NMFS stock assessment report for this area of the Pacific. In summary, northern right whale dolphins are considered extralimital to the TMAA and will not be considered further in this analysis.

3.4.4.4 Risso's Dolphin (*Grampus griseus*)

The Risso's dolphin is distributed worldwide in tropical to warm-temperate waters, roughly between 60°N and 60°S, where surface water temperature is usually greater than 50°F (10°C) (Kruse et al. 1999). The average sea surface temperature for the GOA is reported to be approximately 49.3°F (9.6°C) and has undergone a warming trend since 1957 (Aquarone and Adams 2008). The average summer temperature within the upper 328 ft (100 m) of the TMAA is approximately 52°F (11°C) based on data as presented in the modeling analysis undertaken. In the eastern Pacific, Risso's dolphins range from the GOA to Chile (Leatherwood et al. 1980, Reimchen 1980, Braham 1983, Olavarria et al. 2001). Water temperature appears to be a factor that affects the distribution of Risso's dolphins in the Pacific (Leatherwood et al. 1980, Kruse et al. 1999). Risso's dolphins are expected to be extralimital in the TMAA. They prefer tropical to warm-temperate waters and have been seldom sighted in the cold waters of the GOA. There are a few records of this species near the TMAA. Risso's dolphins have been sighted near Chirikof Island (southwest of Kodiak Island) and offshore in the GOA, just south of the TMAA boundary (Consiglieri et al. 1980, Braham 1983). Based on the above information, there is a very low likelihood of Risso's dolphins being present in the action area, so this species will not be considered in greater detail in the remainder this analysis.

3.4.4.5 Short-Finned Pilot Whale (*Globicephala macrohynchus*)

Short-finned pilot whales should not occur in the TMAA. This species is found in tropical to warm-temperate seas, generally in deep offshore areas and they do not usually range north of 50°N (DoN 2006). There are two records of this species in Alaskan waters. A short-finned pilot whale was taken near Katanak on the Alaska Peninsula in 1937 and a group of five short-finned pilot whales were sighted just southeast of Kodiak Island in May 1977 (DoN 2006). There are no abundance estimates available for this species in the NMFS stock assessment report for this area of the Pacific. In summary, short-finned pilot whales are considered extralimital to the TMAA and will not be considered further in this analysis.

3.4.4.6 Sea Otter (*Enhydra lutris*)

On 16 December 2008, the USFWS proposed to designate critical habitat for the Southwest Alaska stock of the northern sea otter (*Enhydra lutris kenyoni*) under the ESA (Department of the Interior [DOI] 2008). This critical habitat designation was effective as of 9 November 2009. This species is under the federal jurisdiction of the USFWS.

Sea otters occupy and use shorelines and coastal nearshore habitat well outside the boundaries of the TMAA. Sea otters are primarily found within 1-2 km (0.5-1.1 nm) of the shore and/or the 30 fathom (55 m) isobath (DOI 2008, NMFS 2005a). Critical habitat map units boundaries for “Unit 5” in the Kodiak Island area are for nearshore waters within approximately 328 ft (100 m) from the mean high tide line. The closest point from the critical habitat to the TMAA is, therefore, located more than 24 nm (44 km) from the western corner of the TMAA. Sea otters are considered extralimital to the TMAA and none were encountered within the TMAA during the April 2009 GOALS survey (Rone et al. 2009).

3.5 ESTIMATED MARINE MAMMAL DENSITIES

Marine mammal species occurring in the GOA include baleen whales (mysticetes), toothed whales, dolphins, and porpoises (odontocetes), and seals and sea lions (commonly referred to as pinnipeds). Baleen and toothed whales as well as dolphins and porpoises, collectively known as cetaceans, spend their entire lives in the water and spend most of the time (>90 percent 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 percent 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). Sea lions often forage in bouts and then rest at the surface therefore their overall time underwater is much less than a cetacean. When not actively diving, pinnipeds at the surface often hold their heads above the water surface. Consequently, pinnipeds may not be exposed to underwater sounds to the same extent as cetaceans.

For the purposes of this analysis, the Navy has adopted a conservative approach to modeling underwater noise exposure to marine mammals, in that it will tend to overestimate exposures as follows:

- *Cetaceans – assume 100 percent 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 percent of time is spent underwater and therefore exposed to noise.*

3.5.1 Derivation of Marine Mammal Density Estimates for TMAA

Recent survey data for marine mammals in the GOA was limited and most survey efforts were localized and extremely near shore. In addition to the visual surveys, there is evidence of occurrence of several species based on acoustic studies, but these do not provide measurements of abundance (e.g., Stafford 2009).

In April 2009, the Navy funded and NMFS conducted the Gulf of Alaska Line-Transect Survey (GOALS) to address the data needs for this analysis (Rone et al. 2009). Line-transect survey visual data to support distance sampling statistics and acoustic data were collected over a 10-day period both within and outside the TMAA. This survey resulted in sightings of several species and allowed for the derivation of densities for fin and humpback whale (Rone et al. 2009). In addition to this latest survey, two previous vessel surveys conducted in the near shore region of the TMAA were also used to derive the majority of the density data used in acoustic modeling for this analysis. The methods used to derive density estimates for all remaining species in the TMAA are detailed in Appendix B and summarized below.

Zerbini et al. (2006) conducted dedicated vessel surveys for large whales in summer 2001-2003 from Resurrection Bay on the Kenai Peninsula to Amchitka Island in the Aleutian Islands. Survey effort near the TMAA was nearshore (within approximately 46 nm [85 km] of shore), and is delineated as "Block 1" in the original paper. Densities for this region were published for fin and humpback whales.

Waite (2003) conducted vessel surveys for cetaceans near Kenai Peninsula, within Prince William Sound and around Kodiak Island, during acoustic-trawl surveys for pollock in summer 2003. Surveys extended offshore to the 1,000 meter (3,280 feet [ft]) isobath and therefore overlapped with some of the TMAA. Waite (2003) did not calculate densities, but did provide some of the elements necessary for calculating density (see Appendix B).

Mysticetes occurring in the GOA include blue, fin, gray, humpback, minke, North Pacific right, and sei whales which have been sighted in the GOA (Angliss and Allen 2008, Rone et al. 2009). Blue, North Pacific right, and sei whales are considered rare, are too few in number to allow for quantitative analysis, and are included here only for discussion purposes given they are endangered species.

Gray whale density was calculated from data obtained from feeding studies near shore in the GOA. Gray whales are found almost exclusively in near shore areas; therefore, they would not be expected to be found in the majority of the TMAA (>50 nm [93 km] offshore and >5,997 ft [1,828 m] depth). (DoN 2006) The recent 2009 survey encountered one group of two gray whales on the shelf within the western edge of the TMAA and two groups well outside the TMAA near shore at Kodiak Island (Rone et al. 2009).

Odontocetes occurring regularly include sperm whale, Cuvier's, Baird's, and Stejneger's beaked whales, killer whale, Pacific white-sided dolphin, and Dall's porpoise (Angliss and Allen 2008, Rone et al. 2009). In Alaskan waters, harbor porpoises inhabit nearshore areas and are common in bays, estuaries, and tidal channels. In the GOA, harbor porpoise inhabit coastal waters where depths are less than 328 ft (100 m) in depth (DoN 2006, Angliss and Allen 2008). The majority of the TMAA is well offshore of the normal habitat range for harbor porpoise. There is no density data available for this species in the nearshore fraction of the TMAA overlapping the harbor porpoise range. An estimated quantification of impacts for harbor porpoise was, however, undertaken as is described in a subsequent section.

Pinnipeds occurring regularly include Steller sea lion, northern fur seal, and northern elephant seal. California sea lion range extends as far north as the Pribilof Islands in the Bering Sea. Tagging data indicate that most northern fur seal forage and migration takes place to the west of the TMAA (Ream et al. 2005), although the derived density for this species assumed the population would be present in the area for modeling purposes. Harbor seals are primarily a coastal species and are rarely found more than 12 miles (mi) (20 km) from shore (DoN 2006). Harbor seals should be very rare in the TMAA and there was no attempt to model for this species.

Pinniped at-sea density is not often available because pinniped abundance is obtained via shore counts of animals at known rookeries and haulouts. Lacking any other available means of quantification, densities of pinnipeds were derived using shore counts. Several parameters were identified for pinnipeds from the literature, including area of stock occurrence, number of animals (which may vary seasonally) and season, and those parameters were then used to calculate density. Once density per “pinniped season” was determined, those values were prorated to fit the warm water (June-October) and cold water (November-May) seasons. Determining density in this manner is risky as the parameters used usually contain error (e.g., geographic range is not exactly known and needs to be estimated and abundance estimates usually have large variances). As is true of all density estimates, they assume that animals are always distributed evenly within an area which is likely never true.

Table 3-2 presents all available densities of species for the TMAA and pertinent references. Additional information on all species can be found in the Marine Resources Assessment for the GOA Operating Area (DoN 2006). The Marine Resource Assessment listed 6 mysticetes, 12 odontocetes, and 5 pinnipeds as occurring or possibly occurring in the GOA region (DoN 2006; Table 3-1). However, several of the species listed are extralimital to the TMAA. Only species for which densities are available are included in Table 3-2.

3.5.2 Depth Distribution

There is limited depth distribution data for most marine mammals. 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 when the animal returns to the beach. Depth information can also be collected via satellite tags, sonic tags, digital tags, and, for sperm whales, via acoustic tracking of sounds produced by the animal itself.

There are somewhat suitable depth distribution data for a few 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 often must be interpreted from other dive and/or preferred prey characteristics. Depth distributions for species for which no data are available are extrapolated from surrogate species (example in Section 3.4.2.2).

Table 3-2. Summary of Marine Mammal Species, Density, and Information Sources for the TMAA in Summer (April – October)

Species	Density (animal /km^2)	Source
ESA Listed Species		
Fin whale	0.010	Rone et al. (2009)
Humpback whale	0.0019	Rone et al. (2009)
Sperm whale	0.0003	Waite (2003), Mellinger et al. (2004)
Steller sea lion	0.0098	Angliss and Allen (2008), Bonnell and Bowlby (1992)
Non-ESA Listed Species		
Gray whale	0.0125	Moore et al. (2007)
Minke whale	0.0006	Waite (2003)
Baird's beaked whale	0.0005	Waite (2003)
Cuvier's beaked whale	0.0022	Waite (2003)
Dall's porpoise	0.1892	Waite (2003)
Killer whale	0.0100	Zerbini et al. (2007)
Pacific white-sided dolphin	0.0208	Waite (2003)
Northern elephant seal	0.0022	Carretta et al. 2009
Northern fur seal	0.1180	Carretta et al. 2009

Notes: ESA = Endangered Species Act, km^2 = squared kilometers

3.5.3 Density And Depth Distribution Combined

Marine mammal density is nearly always reported for an area as animals per square kilometer (km^2). Analyses of survey results using Distance Sampling techniques 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 [2-D]), 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 is insufficient data to calculate density for small areas. Therefore, assuming an even distribution within the prescribed area remains the norm.

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 (<2,625 ft [<800 m]) and others regularly diving to <656 ft (<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 more accurate three-dimensional (3-D) density estimate is possible. These 3-D estimates allow more accurate modeling of potential marine mammal exposures from specific noise sources. See Appendix B for additional modeling information.

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4 ASSESSMENT OF MARINE MAMMAL SPECIES OR STOCKS THAT COULD POTENTIALLY BE AFFECTED

Marine mammals inhabit most marine environments from deep ocean canyons to shallow estuarine waters. They are not randomly distributed. Marine mammal distribution is affected by demographic, evolutionary, ecological, habitat-related, and anthropogenic factors. This section provides a brief discussion of marine mammal functional hearing groups followed by general descriptions and information regarding marine mammals that may occur within the Gulf of Alaska (GOA) Temporary Maritime Activities Area (TMAA). Marine mammals listed as threatened or endangered under the Endangered Species Act (ESA) are presented in Section 4.2, followed non-listed species in Section 4.3.

Marine mammal movements are often related to seasonal feeding or breeding activity. A migration is the periodic movement of all, or significant components of an animal population from one habitat to one or more other habitats and back again. Migration is an adaptation that allows an animal to monopolize areas where favorable environmental conditions exist for feeding, breeding, and/or other phases of the animal's life history. Some baleen whale species, such as gray whales and humpback whales, make extensive annual migrations to low-latitude mating and calving grounds in the winter and to high-latitude feeding grounds in the summer. Cetacean movements can also reflect the distribution and abundance of prey. Cetacean movements have also been linked to indirect indicators of prey, such as temperature variations, sea-surface chlorophyll-a concentration, sea surface height, and features such as bottom depth (Fiedler 2002). Oceanographic conditions such as upwelling zones, eddies, and turbulent mixing can create regionalized zones of enhanced productivity that are translated into zooplankton concentrations, and/or entrain prey.

4.1 MARINE MAMMAL HEARING AND VOCALIZATION SUMMARY

Cetaceans have an auditory anatomy that follows the basic mammalian pattern, with some changes to adapt to the demands of hearing in the sea. The typical mammalian ear is divided into an outer ear, middle ear, and inner ear. The outer ear is separated from the inner ear by a tympanic membrane, or eardrum. In terrestrial mammals, the outer ear, eardrum, and middle ear transmit airborne sound to the inner ear, where the sound waves are propagated through the cochlear fluid. Since the impedance of water is close to that of the tissues of a cetacean, the outer ear is not required to transduce sound energy as it does when sound waves travel from air to fluid (inner ear). Sound waves traveling through the inner ear cause the basilar membrane to vibrate. Specialized cells, called hair cells, respond to the vibration and produce nerve pulses that are transmitted to the central nervous system. Acoustic energy causes the basilar membrane in the cochlea to vibrate. Sensory cells at different positions along the basilar membrane are excited by different frequencies of sound. Baleen whales have inner ears that appear to be specialized for low-frequency hearing. Conversely, dolphins and porpoises have ears that are specialized to hear high-frequencies. (Au et al. 2000a)

Marine mammal vocalizations often extend both above and below the range of human hearing; vocalizations with frequencies lower than 18 hertz (Hz) labeled as infrasonic and those higher than 20 kilohertz (kHz) as ultrasonic (National Research Council 2003). Measured data on the hearing abilities of cetaceans are sparse, particularly for the larger cetaceans such as the baleen whales. Sensitivity to low-frequency sound by baleen whales has been inferred from observed vocalization frequencies, observed reactions to playback of sounds, and anatomical analyses of the auditory system. Southall et al (2007) has provided a comprehensive review of marine mammal acoustics including designating functional hearing groups. Table 4-1 presents the functional hearing groups and representative species or taxonomic groups for each although most species found in the TMAA fall in the four groups, low-frequency cetaceans (baleen whales), mid-frequency cetaceans (odontocetes), high-frequency cetaceans (harbor porpoises) and pinnipeds in water and air.

The auditory thresholds of some of the smaller odontocetes have been determined in captivity. It is generally believed that cetaceans should at least be sensitive to the frequencies of their own vocalizations. Comparisons of the anatomy of cetacean inner ears and models of the structural properties and the response to vibrations of the ear's components in different species provide an indication of likely sensitivity to various sound frequencies. The ears of small toothed whales are optimized for receiving high-frequency sound, while baleen whale inner ears are best in low to infrasonic frequencies (Ketten, 1992; 1997; 1998).

Table 4-1. Summary of the Five Functional Hearing Groups of Marine Mammals (Based on Southall et al. 2007)

Functional Hearing Group	Estimated Auditory Bandwidth	Species or Taxonomic Groups
Low-Frequency Cetaceans (Mysticetes–Baleen whales)	7 Hz to 22 kHz (best hearing is generally below 1,000 Hz, higher frequencies result from humpback whales[1])	All baleen whales
Mid-Frequency Cetaceans (Odontocetes)	150 Hz to 160 kHz (best hearing is from approximately 10-120 kHz[1])	Most delphinid species including rough-toothed, bottlenose, spinner, common, Fraser's, dusky, hourglass, Peale, white-beaked and white-sided, Risso's and right whale dolphins; medium and large odontocete whales including melon-headed whale, pygmy killer whale, false killer whale, killer whale, pilot sperm whale, beluga whale, narwhal whale, and beaked whales
High-frequency cetaceans (Odontocetes)	200 Hz to 180 kHz (best hearing is from approximately 10-150 kHz[1])	Porpoise species including the harbor, finless, and Dall's porpoise; river dolphins including the Baiji, Ganges, Amazon river dolphins; the dwarf and pygmy sperm whales), and Commerson's, Heaviside and Hector's dolphins
Pinnipeds in water	75 Hz to 75 kHz (best hearing is from approximately 1-30 kHz[1])	All seals, fur seals, sea lions and walrus
Pinnipeds in air	75 Hz to 30 kHz (best hearing is from approximately 1-16 kHz[1])	All seals, fur seals, sea lions and walrus

[1] Estimated best hearing ranges are derived from review and species specific articles (e.g. Richardson et al. 1995, Nedwell et al. 2004, Southall et al. 2007)

Hz = hertz kHz = kilohertz

Baleen whale vocalizations are composed primarily of frequencies below 1 kHz, and some contain fundamental frequencies as low as 16 Hz (Watkins et al., 1987; Richardson et al., 1995; Rivers, 1997; Moore et al., 1998; Stafford et al., 1999; Wartzok and Ketten, 1999) but can be as high as 24 kHz (humpback whale; Au et al. 2006). Clark and Ellison (2004) suggested that baleen whales use low-frequency sounds not only for long-range communication, but also as a simple form of echo ranging, using echoes to navigate and orient relative to physical features of the ocean. Although there is apparently much variation, the source levels of most baleen whale vocalizations lie in the range of 150-190 decibels referenced to 1 micropascal squared per second (dB re 1 µPa^2-s). Low-frequency vocalizations made by baleen whales and their corresponding auditory anatomy suggest that they have best hearing at low-frequencies (Ketten 2000), although specific data on sensitivity, frequency or intensity discrimination, or localization abilities are lacking. Marine mammals, like all mammals, have typical U-shaped audiograms that begin with relatively low sensitivity (high threshold) at some specified low frequency with increased sensitivity (low threshold) to a species specific optimum followed by a generally steep rise at higher frequencies (high threshold) (Fay 1988).

The majority of blue and fin whales vocalizations are less than 222 Hz (Cummings and Thompson 1971, Thompson et al. 1992, Mellinger and Clarke 2003, Rankin et al. 2005). Blue whales produce a variety of low-frequency sounds in a 10-100 Hz band (Cummings and Thompson 1971, Thompson and Friedl 1982, Alling and Payne 1991, McDonald et al. 1995, Clark and Fristrup 1997, Rivers 1997, Stafford et al. 1998, Stafford et al. 1999, McDonald et al. 2001). Off California, the most typical blue whale signals are very long, patterned sequences of tonal infrasonic sounds in the 15-100 Hz range (Aburto et al. 1997, McDonald et al. 2001, Oleson et al. 2007), and are typically infrequently produced by a small subset of males (Calambokidis et al. 2004, Oleson et al. 2007).

Fin whales produce a variety of low-frequency sounds, primarily in the 15-200 Hz band (Watkins 1981, Watkins et al. 1987, Thompson et al. 1992, McDonald and Fox 1999). The most typical signals are long, patterned sequences of short duration (0.5-2 seconds) infrasonic pulses in the 18-35 Hz range (Patterson and Hamilton, 1964; Watkins et al. 1987).

Three sounds are produced by humpback whales: “songs” produced in late fall, winter, and spring by single animals; sounds produced by groups of humpback whales (possibly associated with aggressive behavior among males) on the winter breeding grounds; and sounds produced on the summer feeding grounds. Dominant frequencies of these songs range from 40 Hz to 4 kHz, with components of up to 8 kHz (Thompson et al. 1979, Richardson et al. 1995) and harmonics of the frequency fundamental measured up to 24 kHz (Au et al. 2001, 2006). Source levels average 155 dB re 1 µPa @ 1 m and range from 144 to 174 dB re 1 µPa @ 1 m (Thompson et al. 1979, Au et al. 2006). Sounds often associated with possible aggressive behavior by males are quite different from songs, extending from 50 Hz to 10 kHz (or higher), with most energy in components below 3 kHz (Tyack and Whitehead 1983). Sounds are produced less frequently on summer feeding grounds and are at approximately 20-2,000 Hz, with median durations of 0.2-0.8 seconds and source levels of 175-192 dB re 1 µPa @ 1 m (Thompson et al. 1986). Filter-bank models of the humpback whale’s ear have been developed from anatomical features of the humpback’s ear and optimization techniques (Houser et al. 2001). The results suggest that humpbacks are sensitive to frequencies between 700 Hz and 10 kHz, but best sensitivity is likely to occur between 2 and 6 kHz.

Minke whales produce a variety of sounds, primarily in the 80-5,000 Hz range. In the Northern Hemisphere, sounds recorded include grunts, thumps, and ratchets from 80-850 Hz and pings and clicks from 3-20 kHz (Winn and Perkins, 1976; Thompson et al. 1979, Stewart and Leatherwood 1985, Mellinger et al. 2000, Rankin and Barlow 2003).

The toothed whales produce a wide variety of sounds, which include species-specific broadband “clicks” with peak energy between 10 and 200 kHz, individually variable “burst pulse” click trains, and constant frequency or frequency-modulated whistles ranging from 4 to 16 kHz (Wartzok and Ketten, 1999). The general consensus is that the tonal vocalizations (whistles) produced by toothed whales play an important role in maintaining contact between dispersed individuals, while broadband clicks are used during echolocation (Wartzok and Ketten, 1999). Burst pulses have also been strongly implicated in communication, with some scientists suggesting that they play an important role in agonistic encounters

(McCowan and Reiss, 1995), while others have proposed that they represent "emotive" signals in a broader sense, possibly representing graded communication signals (Herzing, 1996). Sperm whales, however, are known to produce only clicks, which are used for both communication and echolocation (Whitehead, 2003). Most of the energy of toothed whales social vocalizations is concentrated near 10 kHz, with source levels for whistles as high as 100-180 dB re 1 µPa @ 1 m (Richardson et al., 1995). No odontocete has been shown audiometrically to have acute hearing (<80 dB re 1 µPa) below 500 Hz (Southall et al., 2007). Sperm whales produce clicks, which may be used to echolocate (Mullins et al., 1988), with a frequency range from less than 100 Hz to 30 kHz and source levels up to 230 dB re 1 µPa 1 m or greater (Møhl et al., 2000).

General reviews of cetacean and pinniped sound production and hearing may be found in Richardson et al. (1995), Edds-Walton (1997), Wartzok and Ketten (1999), Au et al. (2000a), Nedwell et al. (2004), May-Collado et al. (2007). For a discussion of acoustic concepts, terminology, and measurement procedures, as well as underwater sound propagation, Urick (1983) and Richardson et al. (1995) are recommended.

4.2 ESA-LISTED MARINE MAMMAL SPECIES IN THE TMAA

There are seven marine mammal species within the marine waters of the GOA listed as endangered or threatened under the ESA. These include the blue whale, fin whale, humpback whale, North Pacific right whale, sei whale, sperm whale, and Steller sea lion. As noted previously, beluga whale (Cook Inlet stock) and sea otter should not be present in the TMAA and will not be analyzed further.

4.2.1 Blue whale (*Balaenoptera musculus*)

Stock—Eastern North Pacific

Regulatory Status- Blue whales (*Balaenoptera musculus*) are listed as endangered under the ESA and a recovery plan has been prepared (NMFS 1998b). The Eastern North Pacific (ENP) stock is designated depleted and classified as strategic under the MMPA.

Habitat Preferences and Critical Habitat- Blue whales inhabit both coastal and oceanic waters in temperate and tropical areas (Yochem and Leatherwood 1985). Important foraging areas include the edges of continental shelves and upwelling regions (Reilly and Thayer 1990, Schoenherr 1991). There is an absence of information available for blue whales in Alaska waters. Feeding grounds have been identified in coastal upwelling zones off the coast of California (Croll et al. 1998, Fiedler et al. 1998, Burtenshaw et al. 2004) and Baja California, Mexico (Reilly and Thayer 1990). Blue whales off the coast of southern California appear to feed exclusively on dense schools of krill between 328 and 656 ft (100 and 200 m; Croll et al. 1998, Fiedler et al. 1998). These concentrations form downstream from upwelling centers in close proximity to regions of steep topographic relief off the continental shelf break (Croll et al. 1999). Migratory movements of blue whales in California probably reflect seasonal patterns and productivity (Croll et al. 2005). Blue whales also feed in cool, offshore, upwelling-modified waters in the eastern tropical and equatorial Pacific (Reilly and Thayer 1990, Palacios 1999). Moore et al. (2002) determined that blue whale call locations in the western north Pacific were associated with relatively cold, productive waters and fronts. Stafford et al. (2007), however, reports that the distribution of northeastern Pacific blue whales was not correlated to sea surface temperature.

Critical habitat has not been designated for blue whales.

Population Size and Trends- Two stocks are recognized within U.S. North Pacific waters: the Western North Pacific stock (Hawaiian) and the ENP (NMFS 2006c). The ENP stock includes animals found from the northern GOA to the eastern tropical pacific. There is a minimum population estimate of 1,368

(Coefficient of Variation [CV] = 0.22) individuals in the ENP blue whale stock (Carretta et al. 2007) but no estimates for blue whales are available for the Alaska Stock Assessment (Angliss and Allen 2008). There are insufficient numbers of individuals of this species present in the TMAA to allow for acoustic impact modeling given they are rare.

While it is expected that the north Pacific population of blue whales has increased since being given protected status in 1966, there is no clear information on the population structure or population trend of species. The abundance of blue whales along the California coast has clearly been increasing (Calambokidis et al. 1990, Barlow 1994, Calambokidis 1995). However, the scarcity of blue whales in areas of former abundance (e.g., GOA near the Aleutian Islands) suggests that the potential increasing trend does not apply to the species' entire range in the eastern north Pacific (Calambokidis et al. 1990).

Distribution— Blue whales are distributed from the ice edges to the tropics in both hemispheres. In the North Pacific Ocean, blue whales are sighted from Kamchatka (Russia) to southern Japan in the west, and from the GOA south to at least Costa Rica in the east. Historical areas of concentrations include the eastern GOA, the eastern Aleutians, and the far western Aleutians (DoN 2006).

Blue whales as a species are thought to summer in high latitudes and move into the subtropics and tropics during the winter. A discovery tag on a blue whale by whalers off Vancouver Island in May 1963 was recovered a year later in June 1964 just south of Kodiak Island and a blue whale photoidentified south of Prince William Sound was identified five times between 1995 and 1998 off southern California. These occurrences support the hypothesis that blue whales seasonally migrate to and from feeding areas in the GOA (DoN 2006). Data from both the Pacific and Indian Oceans, however, indicate that some individuals may remain year-round in low latitudes, such as over the Costa Rican Dome. The productivity of the Costa Rican Dome may allow blue whales to feed during their winter calving/breeding season and not fast, like humpback whales are believed to do.

In the GOA, three blue whales were sighted in the summer of 2004 during survey work (Calambokidis et al. 2008). Blue whale calls, with a strong seasonal pattern, have been acoustically detected in the GOA in mid-July to mid-December with the peak occurrence from August through November (Moore et al. 2006, DoN 2006). The area of primary occurrence is seaward of the shelf break, with waters over the shelf area of a secondary occurrence (DoN 2006).

Life History— The eastern North Pacific stock of blue whales feeds in waters from California to Alaska in summer and fall and migrates south to the waters of Mexico to Costa Rica in winter (National Marine Fisheries Service 2006e) for breeding and to give birth (Mate et al. 1999).

Reproduction/Breeding— Calving occurs primarily during the winter (Yochem and Leatherwood 1985) and blue whales move south from feeding areas to give birth. There are no known areas used by blue whales for reproduction or calving in the TMAA.

Diving Behavior— Blue whales spend more than 94 percent of their time below the water's surface (Lagerquist et al. 2000). Croll et al. (2001) determined that blue whales dived to an average of 462 ft (141 m) and for 7.8 minutes (min) when foraging and to 222 ft (68 m) and for 4.9 min when not foraging. Calambokidis et al. (2003) deployed tags on blue whales and collected data on dives as deep as about 984 ft (300 m).

Acoustics— In 1994 off the coast of California, blue whale vocalizations at 17 hertz (Hz) were estimated to have source levels in the range of 195 decibels (dB) referenced to 1 micropascals at a distance of 1 meter (dB re 1 µPa @ 1 m) (Aburto et al. 1997). Blue whale vocalizations are long, patterned low-frequency sounds with durations up to 36 seconds repeated every 1 to 2 min. Their frequency range is 12 to 400 Hz, with dominant energy in the infrasonic range at 12 to 25 Hz (see Table 3.8-3) (Ketten 1998, Mellinger and Clark 2003). Vocalizations of blue whales in Alaska appear be of two distinct types suggestive of separate populations consisting of western Pacific and northeastern Pacific types (Moore et al. 2006). While no data on hearing ability for this species are available, it is hypothesized that mysticetes have excellent low frequency hearing (Ketten 1997).

Impacts of Human Activity

Historic Whaling— Blue whales were occasionally hunted by the sailing-vessel whalers of the 19th century (Carretta et al. 2008). The introduction of steam power in the second half of that century made it possible for boats to overtake large, fast-swimming blue whales and other rorquals. From the turn of the century until the mid-1960s, blue whales from various stocks were intensely hunted in all the world's oceans (NMFS 1998b). Blue whales were protected in portions of the Southern Hemisphere beginning in 1939, but were not fully protected in the Antarctic until 1965. In 1966, they were given complete protection in the North Pacific under the International Convention for the Regulation of Whaling (Gambell 1979, Best 1993). Some illegal whaling by the Union of Soviet Socialist Republics have occurred in the north Pacific (Yablokov 1994); it is likely that blue whales were among the species taken by these operations, but the extent of the catches is not known. Since gaining complete legal protection from commercial whaling in 1966, some populations have shown signs of recovery, while others have not been adequately monitored to determine their status (NMFS 1998b). Removal of this threat has allowed increased recruitment in the population, and therefore, the blue whale population in the eastern north Pacific is expected to have grown.

The blue whale population was severely depleted by commercial whaling in the twentieth century (NMFS 1998b). In the North Pacific, pre-exploitation population size is speculated to be approximately 4,900 blue whales, and the current population estimate is a minimum of 3,300 blue whales (Wade and Gerrodette 1993, NMFS 2006c).

Fisheries Interactions— Because little evidence of entanglement in fishing gear exists and large whales such as the blue whale may often die later and drift further offshore, it is difficult to estimate the numbers of blue whales killed and injured by gear entanglements. The offshore drift gillnet fishery is the only fishery that is likely to take blue whales from this stock, but no fishery mortalities or serious injuries have been observed. In addition, the injury or mortality of large whales due to interactions or entanglements in fisheries may go unobserved because large whales swim away with a portion of the net or gear. Fishermen have reported that large whales tend to swim through their nets without entangling and causing little damage to nets. (Carretta et al. 2008)

Ship Strikes— There is no record of any ship strike involving a blue whale in Alaska waters (Jensen and Silber 2004). According to NMFS, the average number of blue whale mortalities in California attributed to ship strikes was 0.6 whales per year for 2002-2006 (Carretta et al. 2008). As recently as September 2007, commercial vessels were implicated in the deaths of three blue whales in the Santa Barbara Channel off southern California. Additional mortality from ship strikes probably goes unreported because the whales do not strand, or if they do, they do not always have obvious signs of trauma. However, several blue whales have been photographed in California with large gashes in their dorsum that appear to be from ship strikes. (Carretta et al. 2008)

4.2.2 Fin whale (*Balaenoptera physalus*)

Stock—Northeast Pacific

Regulatory Status- Fin whales (*Balaenoptera physalus*) are listed as endangered under the ESA. The Northeast Pacific stock is designated as depleted and classified as strategic under the MMPA. A draft species recovery plan for fin whales has been prepared (NMFS 2006b).

Habitat Preferences and Critical Habitat- Fin whales are found in continental shelf, slope, and oceanic waters (Gregr and Trites 2001, Reeves et al. 2002). Globally, this species tends to be aggregated in locations where populations of prey are most plentiful, irrespective of water depth, although those locations may shift seasonally or annually (Payne et al. 1986, 1990; Kenney et al. 1997; Notarbartolo-di-Sciara et al. 2003). Littaye et al. (2004) determined that fin whale distribution in the Mediterranean Sea was linked to frontal areas and upwelling within large zooplankton patches. Fin whales in the north Pacific spend the summer feeding along the cold eastern boundary currents and appear to prefer krill and large copepods, but also eat schooling fish such as Pacific herring (*Clupea harengus pallasi*), walleye pollock (*Theragra chalcogramma*), and capelin (*Mallotus villosus*) (Nemoto and Kawamura 1977, Perry et al. 1999). Critical habitat has not been designated for fin whales.

Population Size and Trends- In the north Pacific, the total pre-exploitation population size of fin whales is estimated at 42,000 to 45,000 whales (Ohsumi and Wada 1974). From whaling records, fin whales that were marked in winter 1962 to 1970 off southern California were later taken in commercial whaling operations between central California and the GOA in summer (Mizroch et al. 1984). In summer 2003, a cetacean survey in the Shelikof Strait (north of Kodiak), Cook Inlet, Prince William Sound and on the shelf between Kodiak and Montague Island detected 165 fin whales along the shelf break and having an average group size of 2.9 observed over 57 sightings (Waite 2003). The April 2009 GOALS survey in the TMAA had 24 visual observations of fin whale groups totaling 64 individuals during a 10-day period (Rone et al. 2009).

Currently there are no reliable estimates of current or historical abundance numbers for the Northeast Pacific fin whale stock. Fin whales have a worldwide distribution, with three distinct stocks recognized in the Pacific: (1) Alaska (Northeast Pacific), (2) California/Washington/ Oregon, and (3) Hawaii. Provisional estimates for the Northeastern Pacific based on surveys in 1999 and 2000 are 3,368 (CV = 0.18) for the central-eastern Bering Sea and 683 (CV = 0.32) for the eastern Bering Sea. (Angliss and Allen 2008)

The population trend for this species estimated for 1987 to 2003 is reported as growing at 4.8 percent annually, which is consistent with estimated the growth rates of other large whales (Angliss and Allen 2008). For purposes of acoustic impact modeling, a density of 0.010 individuals per km^2 was used for fin whales in the TMAA as provided by Rone et al. (2009) and described in detail in Appendix B.

Distribution— Fin whales are broadly distributed throughout the world's oceans, usually in temperate to polar latitudes and less commonly in the tropics (Reeves et al. 2002). Single fin whales are most common, but they gather in groups, especially when good sources of prey are aggregated.

Fin whales in the North Pacific spend the summer feeding along the cold eastern boundary currents and have been observed as far north as the Chukchi and Bering Seas (Gambell 1985, Perry et al. 1999, DoN 2006, Angliss and Allen 2008). However, although fewer in number, fin whales have also been sighted in the Bering Sea all winter (Mizroch et al. 1999). Acoustic signals from fin whales are detected year-round in the GOA with most calls from August through February (Moore et al. 2006, Mizroch et al. 2009). Around Kodiak Island (in the vicinity of the TMAA) fin whales have been observed year-round with most sightings from April to September (DoN 2006).

Life History— Natural sources and rates of mortality are largely unknown, but Aguilar and Lockyer (1987) suggest annual natural mortality rates may range from 0.04 to 0.06 (based on studies of northeast Atlantic fin whales). The occurrence of the nematode *Crassicauda boopis* appears to increase the potential for kidney failure in fin whales and may be preventing some fin whale stocks from recovering from whaling (Lambertsen 1992). Killer whale or shark attacks may result in serious injury or death in very young and sick whales (Perry et al. 1999).

Reproduction/Breeding— Fin whales become sexually mature between 6 to 10 years of age, depending on density-dependent factors (Gambell 1985). Reproductive activities for fin whales occur primarily in the winter. Gestation lasts about 12 months and nursing occurs for 6 to 11 months (Perry et al. 1999). Although fin whales are present in GOA in the winter, there are no known calving areas in GOA (Mizroch et al. 2009) Peak calving is in October through January (Hain et al. 1992) and fin whales likely move south from feeding areas to give birth. There are no known areas used by fin whales for reproduction or calving in the TMAA.

Diving Behavior— Details of diving behavior and the derivation of parameters used in the acoustic modeling are presented in Appendix B. Kopelman and Sadove (1995) found significant differences in blow intervals, dive times, and blows per hour between surface feeding and nonsurface-feeding fin whales. Various researchers have reported foraging fin whales have dive durations of approximately 4 to 15 min and to depths between approximately 200 and 500 ft (61 and 152 m) (DoN 2006). Dives are followed by sequences of four to five blows at 10- to 20-second (sec) intervals (Cetacean and Turtle Assessment Program [CETAP] 1982, Stone et al. 1992, Lafortuna et al. 2003).

Acoustics— Fin whales produce calls with the lowest frequency and highest source levels of all mysticetes. Fin whales produce a variety of sounds with a frequency range from 15 to 750 Hz (see Table 3.8-3). The long-patterned 15- to 30-Hz vocal sequence 1 second in duration with a source level of 184 to 200 dB re 1 Pa @ 1 m is most typically recorded (Richardson et al. 1995, Charif et al. 2002). Only males are known to produce infrasonic pulses, suggesting they may function as a male breeding display (Croll et al. 2002, Moore et al. 2006). Although data on hearing ability for fin whales are unavailable, it is hypothesized that based on their anatomy and vocalizations, fin whales have acute infrasonic hearing (Ketten, 1997).

Impacts of Human Activity

Historic Whaling— Between 1947 and 1987, approximately 46,000 fin whales were taken from the North Pacific by commercial whalers. In addition, approximately 3,800 were taken off the west coast of North America between 1919 and 1929. In 1976 Fin whales in the North Pacific were given protected status by the IWC. (Carretta et al. 2008)

Fisheries Interactions— The incidental take of fin whales in fisheries is extremely rare. In the California/Oregon drift gillnet fishery, observers recorded the entanglement and mortality of one fin whale, in 1999, off southern California (NMFS 2000). Based on a worst-case scenario, NMFS estimates that a maximum of six fin whales (based on calculations that adjusted the fin whale observed entangled and killed in 1999 by the number of sets per year) could be captured and killed in a given year by the California-Oregon drift gillnet fleet (NMFS 2000). Anecdotal observations from fishermen suggest that large whales swim through their nets rather than get caught in them (NMFS 2000). Because of their size and strength, fin whales probably swim through fishing nets, which might explain why these whales are rarely reported as having become entangled in fishing gear. NMFS has no records of fin whales being killed or injured by commercial fisheries operating in the North Pacific (Ferrero et al., 2000).

Vessel Collisions— Worldwide historical records indicate fin whales were the most likely species to be struck by vessels (Laist et al. 2001). For Alaska waters, the available whale-vessel collision data has been presented in an unpublished preliminary summary of opportunistically collected reports involving 62 whale-vessel collisions between 1978 and 2006 (Gabriele et al., manuscript on file). Recognizing that this report is likely biased toward near shore reports and inland waters of Southeast Alaska where the authors were located and where nearshore vessels and a population of humpback whales overlap, there have been no recorded vessel collisions with fin whales in Alaska waters.

4.2.3 Humpback Whale (*Megaptera novaeangliae*)

Stock—Central and Western North Pacific

Regulatory Status— Humpback whales are listed as endangered under the ESA. They are designated as depleted throughout their range under the MMPA and the Western North Pacific stock is classified as strategic. A final species recovery plan has been prepared (NMFS 1991).

In addition to being listing as endangered, there are regulations that have been issued governing the approach to humpback whales in Alaska waters, "within 200 miles of the coast" (NOAA 2001b). These regulations were issued to manage the threat caused by whale watching activities by: (1) prohibiting approach to within 100 yards (yd) (91.4 m) of humpback whales; (2) implementation of a "slow safe speed" in proximity to humpbacks, and (3) creating exemptions for some vessels including military vessels engaged in "official duty" (training).

Habitat Preferences and Critical Habitat- Although humpback whales typically travel over deep, oceanic waters during migration, their feeding and breeding habitats are mostly in shallow, coastal waters over continental shelves (Clapham and Mead 1999). Shallow banks or ledges with high sea-floor relief characterize feeding grounds (Payne et al. 1990, Hamazaki 2002). The habitat requirements of wintering humpbacks appear to be determined by the conditions necessary for calving and breeding consisting mainly of relatively shallow or protected areas around and between islands, over banks, and along continental coasts. Critical habitat has not been designated for humpback whales in the North Pacific.

Population Size and Trends— Three Pacific stocks of humpback whales are recognized in the Pacific Ocean and include the Western North Pacific stock, Central North Pacific stock, and ENP stock (Calambokidis et al. 1997, Baker et al. 1998). In the entire North Pacific Ocean basin prior to 1905, it is estimated that there were 15,000 humpback whales basin-wide (Rice 1978). Whaling in the North Pacific continued until 1976 by the Japanese and Soviet pelagic whaling fleets. After the end of commercial whaling, approximate humpback numbers were estimated to be between 1,200 to 1,400 whales (Calambokidis et al. 2008), although it is unclear if estimates were for the entire north Pacific or just the eastern north Pacific. The population of humpbacks in the Pacific is increasing and has undergone substantial recovery since the end of whaling. The Structure of Populations, Levels of Abundance and Status of Humpback Whales in the North Pacific (SPLASH) study suggested the current (2008) best estimate for the overall abundance in the North Pacific is 18,302 (Calambokidis et al., 2008).

It has been recently estimated there are 3,000 to 5,000 humpback whales are in the GOA area (Calambokidis et al. 2008). The best abundance estimate for the Central North Pacific Stock, is 4,005 (CV = 0.095) individuals (Angliss and Allen 2008). In summer 2003, a survey in the Shelikof Strait (north of Kodiak), Cook Inlet, Prince William Sound and between Kodiak and Montague Island detected 128 humpbacks whales along the shelf break and having an average group size of 2.7 (Waite 2003). An April 2009 survey in the TMAA had 11 visual observations of humpback groups totaling 20 individuals during a 10-day period (Rone et al. 2009). Density for the entire TMAA was 0.0019/km^2 (Table 9, Rone et al. 2009) for the April-December timeframe (Table 3-2) as described in detail in Appendix B. As the humback whales tend to prefer shallow water and are concentrated nearshore over the shelf, this is likely an overestimate for humpback density in the TMAA.

Distribution— Humpback whales live in all major ocean basins from equatorial to subpolar latitudes, migrating from tropical breeding areas to polar or subpolar feeding areas (Jefferson et al. 1993, NMFS 2006c). North Pacific humpback whales are distributed primarily in four more-or-less distinct wintering areas: the Ryukyu and Ogasawara (Bonin) Islands (south of Japan), the Hawaiian Islands, the Revillagigedo Islands off Mexico, and along the coast of mainland Mexico (Calambokidis et al. 2008). There is known to be some interchange of whales among different wintering grounds, and matches between Hawaii and Japan and Hawaii and Mexico have been found (Calambokidis et al. 2008). However, it appears that the overlap is relatively small between the western north Pacific humpback whale population and Central North Pacific and ENP populations (Calambokidis et al. 2008).

Humpbacks in the Pacific are generally found during the summer on high-latitude feeding grounds in a nearly continuous band from southern California to the Aleutian Islands, Kamchatka Peninsula, and the Bering and Chukchi seas (Calambokidis et al. 2001). The U.S./Canada border is an approximate geographic boundary between the California and Alaska feeding groups (Carretta et al. 2006). There is much interchange of whales among different feeding grounds, although some site fidelity occurs.

During the winter, humpbacks generally migrate to the tropics and subtropics where they can be found around islands, over shallow banks, and along continental coasts, where calving and breeding occur. Humpbacks have one of the longest migrations known for any mammal with individuals traveling nearly 4,320 nm (8,000 km) between feeding and breeding areas (Clapham and Mead 1999). Most humpback whale sightings are in nearshore and continental shelf waters; however, humpback whales frequently travel through deep water during migrations such as the route to and from the Hawaiian Islands (Clapham and Mattila 1990, Calambokidis et al. 2001). Migratory transits between the Hawaiian Islands and southeastern Alaska have been documented to take as little as 36 to 39 days (Gabriele et al. 1996, Calambokidis et al. 2001).

In the GOA, peak abundance occurs in late November and early December and slowly declines in January as humpback whales migrate to southerly breeding grounds (Consiglieri et al. 1982, Straley 1990, DoN 2006). Humpback whales that have migrated south begin to return to Alaskan feeding grounds in April (Consiglieri et al. 1982).

Identifications made between feeding areas and wintering areas indicate that the majority of humpbacks in the GOA winter in Hawaii (about 57 percent of the population) with the remainder wintering in Mexican waters around the Revillagigedo Islands, Baja, and the Mexican mainland (Calambokidis et al. 2008). Whales from Southeast Alaskan waters almost exclusively go to Hawaii. However, approximately 15 to 17 percent of the whales identified in the Western GOA could not be matched to known wintering areas, suggesting the existence of undocumented humpback wintering area(s) (Calambokidis et al. 2008). As noted previously, a small number of humpbacks humpback whales occur in the GOA year-round (DoN 2006).

Life History— Humpbacks primarily feed on small schooling fish and krill (Angliss and Allen 2008). The whales primarily feed along the shelf break and continental slope (Green et al. 1992, Tynan et al. 2005).

Reproduction/Breeding— Humpback whales migrate to calving/breeding grounds (e.g., Hawaii and Central America) in the lower latitudes each winter (Calambokidis et al. 2008). There are no known areas used by humpback whales for reproduction or calving in the TMAA.

Diving Behavior— Details of diving behavior and the derivation of parameters used in the acoustic modeling are presented in Appendix B. Humpback whale diving behavior depends on the time of year (Clapham and Mead 1999). In summer, most dives last less than 5 min; those exceeding 10 min are atypical. Although humpback whales have been recorded to dive as deep as about 1,638 ft (500 m) (Dietz et al. 2002), on the feeding grounds they spend the majority of their time in the upper 400 ft (120 m) of the water column (Dolphin 1987, Dietz et al. 2002). In winter, dives average 10 to 15 min; dives of greater than 30 min have been recorded (Clapham and Mead 1999) and with recorded dives to 577 ft (176 m) (Baird et al. 2000).

Acoustics— Humpback whales produce three classes of vocalizations: (1) "songs" in the late fall, winter, and spring by solitary males primarily on wintering grounds and much less frequently on northern feeding grounds; (2) sounds made within groups on the wintering (calving) grounds; and (3) social sounds made on the feeding grounds (Thomson and Richardson 1995). The best-known types of sounds produced by humpback whales are songs, which are thought to be breeding displays used only by adult males (Helweg et al. 1992). Singing is most common on breeding grounds during the winter and spring, but is occasionally heard on feeding grounds outside breeding areas and season (Matilla et al. 1987, Clark and Clapham 2004). There is geographical variation in humpback whale song, with different populations singing different songs, and all members of a population using the same basic song. The song evolves over the course of a breeding season, but remains nearly unchanged from the end of one season to the start of the next (Payne et al. 1983). Social calls are from 50 Hz to over 10 kilohertz (kHz), with the highest energy below 3 kHz (Silber, 1986).

Female humpback whale vocalizations appear to be simple: Simão and Moreira (2005) noted little complexity. The male song, however, is complex and changes between seasons. Components of the song range from under 20 Hz to 4 kHz and occasionally 8 kHz, at source levels of 144 to 174 dB re 1 µPa @ 1 m, with a mean of 155 dB re 1 µPa @ 1 m. The main energy lies between 0.2 and 3.0 kHz, with frequency peaks at 4.7 kHz (Table 3.8-3). Au et al. (2001) reported source levels (between 171 and 189 dB re 1 µPa @ 1 m) of humpback whale songs.

No tests of humpback whale hearing have been made. Houser et al. (2001) constructed a humpback audiogram using a mathematical model based on the internal structure of the ear. The predicted audiogram indicates sensitivity to frequencies from 700 Hz to 10 kHz, with maximum relative sensitivity between 2 kHz and 6 kHz. Au et al. (2006) took recordings of whales off Hawaii and found high-frequency harmonics of songs extending beyond 24 kHz, which may indicate that they can hear at least as high as this frequency. A single study suggested that humpback whales responded to mid-frequency active (MFA) sonar (3.1 to 3.6 kHz) sound (Maybaum 1989). The hand-held sonar system had a sound artifact below 1,000 Hz which caused a response to the control playback (a blank tape) and may have affected the response to sonar (i.e., the humpback whale responded to the low-frequency artifact rather than the MFA sonar sound).

Impacts of Human Activity

Historic Whaling— Commercial whaling, the single most significant population impact on humpback whales, ceased operation in the Pacific Ocean in 1966. Intensive commercial whaling removed more than 28,000 animals from the North Pacific during the 20th century. From 1961 to 1971, an additional 6,793 humpback whales were killed illegally by the former Soviet Union. Many animals during this time were taken from the GOA and Bering Sea; however, catches occurred across the North Pacific, from the Kuril Islands to the Queen Charlottes, and additional illegal catches in earlier years may have gone unrecorded. (Angliss and Allen 2008)

Fisheries Interactions— Entanglement in fishing gear poses a threat to individual humpback whales throughout the Pacific. A number of fisheries based out of West Coast ports may incidentally take the ENP stock of humpback whales, and documented interactions are summarized in the U.S. Pacific Marine Mammal Stock Assessments: 2006 (Carretta et al. 2007). The estimated impact of fisheries on the ENP humpback whale stock is probably underestimated; the serious injury or mortality of large whales from entanglement in gear may go unobserved because whales swim away with a portion of the net, line, buoys, or pots. In 1996 and again in 2001, gear traced to fishing activities in Alaska were removed from two entangled humpback whales in Hawaii. According to the NMFS Pacific Islands Region Marine Mammal Response Network Activity Update (dated July 2007 [NMFS 2007]), there were reports of 26 distressed marine mammals in Hawaii found entangled in fishing gear for the 6-month period, November to April 2007.

NMFS estimates that between 2002 and 2006, there were incidental serious injuries to 0.2 humpback annually in the Bering Sea/Aleutian Islands sablefish longline fishery. This estimation is not considered reliable. Observers have not been assigned to a number of fisheries known to interact with the Central and Western North Pacific stocks of humpback whale. In addition, the Canadian observation program is also limited and uncertain. (Angliss and Allen 2008)

Ship Strikes— Humpback whales, especially calves and juveniles, are highly vulnerable to ship strikes and other interactions with nonfishing vessels. Younger whales spend more time at the surface, are less visible, and are found closer to shore (Herman et al. 1980, Mobley et al. 1999), thereby making them more susceptible to collisions. Nine ship strikes were implicated in mortality or serious injuries of humpback whales between 2001 and 2005. Seven of these ship strikes occurred in Southeast Alaska and two occurred in the northern portion of the Central North Pacific's range (Angliss and Allen 2008). Additional mortality from ship strikes probably goes unreported because the whales do not strand or, if they do, they do not have obvious signs of trauma.

Whale-watching tours are becoming increasingly popular, and ship strikes have risen in recent years. Regulations governing the approach to humpback whales in Alaska were promulgated in 2001 to manage the threat caused by whale watching activities (NOAA 2001b). Two whale watch vessel strikes in Alaska waters have also involved humpback whales (Jensen and Siber, 2004). Available whale-vessel collision data presented in an unpublished preliminary summary indicates that most of the 62 recorded collisions between vessels and whales in Alaska waters involve humpback whales (Gabriele et al., manuscript on file).

As noted previously, many of the humpbacks feeding in GOA winter in Hawaii. In the Hawaiian Islands, ship strikes of the humpback whale are of particular concern. According to the NMFS Pacific Islands Region Marine Mammal Response Network Activity Update (dated January 2007 [NMFS 2007]), there were nine reported collisions with humpback whales in 2006 (none involved the Navy).

Whale Watching Disturbance— Whale-watching boats and scientific research vessels specifically direct their activities toward whales, and may have direct or indirect impacts on humpback whales. The growth of the whale-watching industry has not increased as rapidly for the ENP stock of humpback whales as it has for the Central North Pacific stock (wintering grounds in Hawaii and summering grounds in Alaska), but whale-watching activities do occur throughout the ENP stock's range. There is concern regarding the impacts of close vessel approaches to large whales because harassment may occur, preferred habitats may be abandoned, and fitness and survivability may be compromised if disturbance levels are too high. While a 1996 study in Hawaii measured the acoustic noise of different whale-watching boats (Au and Green 2000) and determined that the sound levels were unlikely to produce grave effects on the humpback whale auditory system, the potential direct and indirect effects of harassment due to vessels cannot be discounted. Several investigators have suggested that shipping noise may have caused humpback whales to avoid or leave feeding or nursery areas (Jurasz and Jurasz 1979, Dean et al. 1985), while others have suggested that humpback whales may become habituated to vessel traffic and its associated noise. Still other researchers suggest that humpback whales may become more vulnerable to vessel strikes once they habituate to vessel traffic (Swingle et al. 1993, Wiley et al. 1995).

Other Threats— Humpback whales are potentially affected by a resumption of commercial whaling, loss of habitat, loss of prey (for a variety of reasons including climate variability), underwater noise, and pollutants. Very little is known about the effects of organochlorine pesticides, heavy metals, polychlorinated biphenyls, and other toxins on baleen whales, although the impacts may be less than higher trophic level odontocetes due to baleen whales' lower levels of bioaccumulation from prey (Angliss and Allen 2008).

Anthropogenic noise may also affect humpback whales, because humpback whales seem to respond to moving sound sources, such as whale-watching, fishing, and recreational vessels and low-flying aircraft (Richardson et al. 1995). Their responses to noise are variable and affected by the context of the exposure and the animal's experience, motivation, and conditioning (Wartzok et al. 2003, Southall et al. 2007).

4.2.4 North Pacific Right Whale (*Balaenoptera musculus*)

Stock—Eastern North Pacific

Regulatory Status— North Pacific right whales (*Eubalaena robustus*) are classified as endangered under the ESA and are considered one of the world's most endangered large whale species. The right whale is designated as depleted and the ENP stock is classified as strategic under the MMPA. (DoN 2006)

Habitat Preferences and Critical Habitat- Feeding habitat for right whales is defined by the presence of sufficiently high densities of prey, especially zooplankton (calanoid copepods). Development of those patches is essentially a function of oceanic conditions, such as stratification, bottom topography, and currents which concentrate zooplankton, and concentration is probably enhanced by the behavior of the organisms themselves. The apparent shift in Bering Sea right whale occurrences from deep waters in the mid-twentieth century to the mid-shelf region in the late 1900s was attributed to changes in the availability of optimal zooplankton patches, possibly relating to climatic forcing (variability in oceanic conditions caused by changes in atmospheric patterns). Sightings in the Bering Sea have been clustered in relatively shallow water (waters with a bottom depth of 164 to 262 ft (50 to 80 m). Information from a tagged individual documented movement between the middle and outer portions of the continental shelf in the Bering Sea, which is consistent with historical distribution patterns. Additionally, sightings of some other right whale individuals during the 2004 survey were made on the outer continental shelf. (DoN 2006)

North Pacific right whales in locations other than Alaska waters have been sighted in even deeper depths, as evidenced by a sighting off California with a bottom depth as deep as 5,577 ft (1,700 m). The International Whaling Commission (IWC) noted a surprising absence of evidence for coastal calving grounds, since right whales in the North Atlantic and in the Southern Hemisphere have calving grounds located in shallow bays, lagoons, or in waters over the continental shelf. (DoN 2006)

Sightings of North Pacific right whales in 1996 during an Alaska Fisheries Science Center groundfish assessment cruise led to intense photoidentification and vessel surveys from 1998 to 2004 in the south-eastern Bering Sea. According to Moore et al. (2006), the sighting locations indicated that right whales preferred the relatively shallow waters of the southeastern Bering Sea middle shelf, which are approximately 230 ft (70 m) in depth. Also determined during these surveys was that right whale calls occurred from May through November, with the greatest number of calls recorded in September and October. (Moore et al. 2006)

In July 1998, a lone North Pacific right whale was sighted among humpback whales during an aerial survey southeast of Kodiak Island. Acoustic surveys of this area produced very few north Pacific right whale calls; however, unambiguous right whale calls were detected in August and early September in western GOA. In addition calls were recorded from locations where right whales were formerly abundant but have not been seen in recent decades. (Moore et al. 2006)

In August 2004, a NMFS researcher observed a single right whale among a group of humpbacks. In August 2005, a NMFS researcher reported yet another sighting of a right whale within 820 to 1,640 ft (250 to 500 m) of groups of humpback and fin whales. (Angliss and Allen 2008) There were no right whales detected acoustically or visually during the April 2009 survey of the TMAA (Rone et al. 2009).

In May 2008, NMFS issued a final rule designating two areas as North Pacific right whale critical habitat, one in the GOA and one in the Bering Sea. The location of the critical habitat for North Pacific right whales in the GOA is shown on Figure 4-1. This area is located beyond approximately 16 nm (30 km) west of the southwest corner of the TMAA. The final rule for this critical habitat designation cites consistent sightings of right whales—both single individuals and pairs—in specific areas in spring and summer over an extended period as an indicator of primary constituent element (dense concentrations of prey) in a feeding area. While sightings of right whales are fewer in number in the GOA than in the Bering Sea, just prior to the final rule three individuals were sighted in the critical habitat area in the GOA. (Angliss and Allen 2008)

Population Size and Trends— There are no reliable estimates of current abundance or trends for right whales in the North Pacific, and the population may only number at least in the low hundreds (Angliss and Allen 2008). The population in the eastern north Pacific is considered to be very small, perhaps only in the tens of animals. An analysis of both photoidentification and biopsy efforts in 2004 in the Bering Sea revealed 17 individuals. However, of 13 individual animals photographed during aerial surveys in 1998, 1999, and 2000, 2 have already been rephotographed. This photographic recapture rate is consistent with a very small population size (Angliss and Outlaw 2006). Over the past 40 years, most sightings in the eastern north Pacific have been of single whales. However, during the last few years, small groups of right whales have been sighted (such as the group of 17 documented in 2004; Angliss and Allen 2008). Observers in 2002 and 2004 reported one confirmed calf sighting and two probable calves (Angliss and Allen 2008). There are not sufficient numbers of individuals of this species present in the TMAA to allow for acoustic impact modeling, given they are rare.

Distribution— Right whales occur in subpolar to temperate waters. They are generally migratory, with at least a portion of the population moving between summer feeding grounds in temperate or high latitudes and winter calving areas in warmer waters (DoN 2006). However, Right whale calls have been detected as early as May and as late as November in southeast Bering Sea region (Munger et al. 2008).

Current distribution patterns and migration routes of North Pacific right whales are not known. Historical whaling records provide virtually the only information on North Pacific right whale distribution. North Pacific right whales historically occurred across the Pacific Ocean north of 35°N, with concentrations in the GOA south of Kodiak Island, the eastern Aleutian Islands, south-central Bering Sea, Okhotsk Sea, and the Sea of Japan. Presently, sightings are extremely rare, occurring primarily in the Okhotsk Sea and the eastern Bering Sea in roughly the same location. There is evidence that the GOA was used as a feeding ground, and recent surveys suggest that some individuals continue to use the shelf east of Kodiak as a feeding area, which has now been designated as critical habitat. It is not known whether there is an interchange between the Bering Sea and GOA areas; for example, an individual right whale that was photographed off Kodiak Island did not match to any photographs of individuals seen in the Bering Sea (DoN 2006, Moore et al. 2006).

The area of densest concentration of North Pacific right whales in the GOA is roughly east from 170°W to 150°W and south to 52°N. (DoN 2006). In GOA off Kodiak Island, sightings of a single lone right whale have occurred in 1998, 2004, 2005, and 2006 (Angliss and Allen 2008). Many of the recent sightings of right whales in GOA are individuals seen in association with humpback whales.

There have since been 10 acoustic detections of probable right whale calls off the continental shelf near Kodiak Island (Moore et al. 2006).

The highly endangered status of North Pacific right whales necessitates an extremely conservative determination of this species' occurrence in the GOA. Right whales will be rare in the TMAA due to the small number in population. There is sparse survey effort during the winter, and this species is believed to be largely absent in Alaska waters during December through April. It is assumed right whales would be

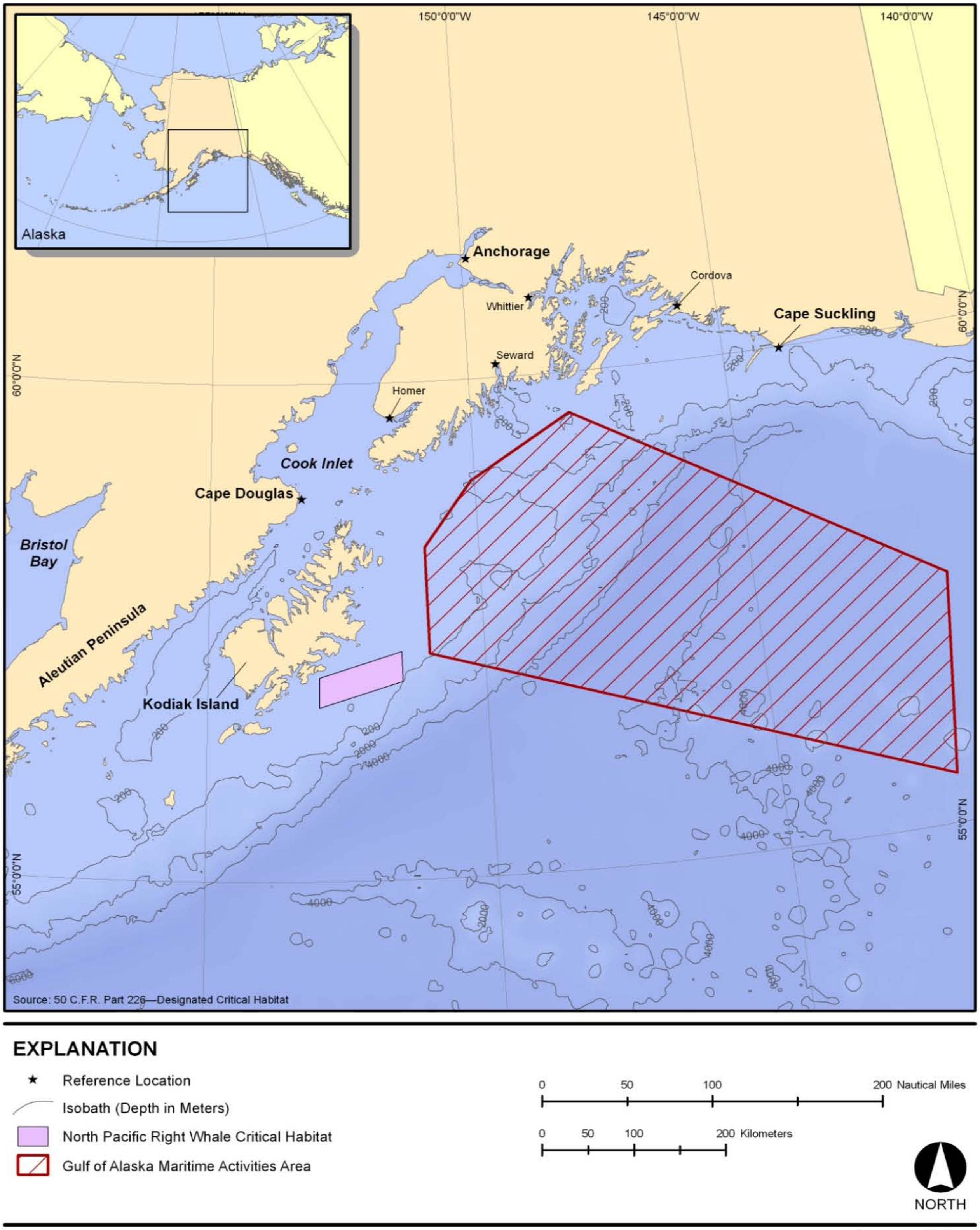

Figure 4-1. North Pacific Right Whale Critical Habitat in the Vicinity of the TMAA

on their breeding grounds, which are likely located further south, although the location of the breeding grounds is unknown. (DoN 2006)

Life History— Feeding habitat for right whales is defined by the presence of sufficiently high densities of prey, especially calanoid copepods. Development of those patches is essentially a function of oceanic conditions, such as stratification, bottom topography, and currents which concentrate zooplankton, and concentration is probably enhanced by the behavior of the organisms themselves. The apparent shift in Bering Sea right whale occurrences from deep waters in the mid-twentieth century to the mid-shelf region in the late 1900s was attributed to changes in the availability of optimal zooplankton patches, possibly relating to climatic forcing (variability in oceanic conditions caused by changes in atmospheric patterns). Sightings in the Bering Sea are clustered in relatively shallow water (waters with a bottom depth of 50 m to 80 m [164 to 262 ft]). Recently, however, a tagged individual moved between the middle and outer portions of the continental shelf in the Bering Sea, which is consistent with historical distribution patterns. Additionally, sightings of some other right whale individuals during the 2004 survey were made on the outer continental shelf. In other locations, North Pacific right whales have been sighted in even deeper waters, as evidenced by a sighting off California in waters with a bottom depth as deep as 1,700 m (5,577 ft). The IWC noted a surprising absence of evidence for coastal calving grounds, since right whales in the North Atlantic and in the Southern Hemisphere have calving grounds located in shallow bays, lagoons, or in waters over the continental shelf. (DoN 2006)

Reproduction/Breeding— The location of calving grounds for the eastern North Pacific population is unknown. There were no records in the last 100 years of newborn or very young calves in the eastern North pacific until 2004 when the presence of at least two calves was documented in the eastern Bering Sea. (DoN 2006) There are no known areas used by right whales for reproduction or calving in the TMAA.

Diving Behavior— There is almost nothing known of North Pacific right whale diving abilities. Dives of 5 to 15 min or even longer have been reported for North Atlantic right whales. Observations of North Atlantic right whales found that the average depth dive was strongly correlated with both the average depth of peak copepod abundance and the average depth of the bottom mixed layer's upper surface. North Atlantic right whale feeding dives are characterized by a rapid descent from the surface to a particular depth between 262 and 574 ft (80 and 175 m), remarkable fidelity to that depth for 5 to 14 min, and then rapid ascent back to the surface. Longer surface intervals have been observed for reproductively active females and their calves. (DoN 2006)

Acoustics— North Pacific right whale calls are classified into five categories: (1) up, (2) down-up, (3) down, (4) constant, and (5) unclassified. The "up" call is the predominant type and is typically a signal sweeping from about 90 to 150 Hz in 0.7 sec. Right whales commonly produce calls in a series of 10 to 15 calls lasting 5 to 10 min, followed by silence lasting an hour or more. Some individuals do not call for periods of at least 4 hours. Morphometric analyses of the inner ear of right whales resulted in an estimated hearing frequency range of approximately 0.01 to 22 kHz.

Nowacek et al. (2004, 2007) documented observations of the behavioral response of North Atlantic right whales exposed to alert stimuli (containing mid-frequency components) in an experiment to help develop a potential ship strike avoidance tool. To assess risk factors involved use of the tool, a multisensor acoustic tag was used to measure the responses of whales to passing ships and experimentally tested their responses to the controlled exposures to various alert stimuli sounds, which included recordings of ship noise, the social sounds of conspecifics, and a signal designed to alert the whales. The alert signal was 18 min of exposure consisting of three 2-min signals played sequentially three times over. The three signals had a 60-percent duty cycle and consisted of (1) alternating 1-sec pure tones at 500 Hz and 850 Hz; (2) a 2-sec logarithmic down-sweep from 4,500 Hz to 500 Hz; and (3) a pair of low (1,500 Hz) to high (2,000

Hz) sine wave tones amplitude modulated at 120 Hz and each 1-sec long. The purposes of the alert signal were (1) to provoke an action from the whales via the auditory system with disharmonic signals that cover the whales' estimated hearing range, (2) to maximize the signal to noise ratio (obtain the largest difference between background noise), and (3) to provide localization cues for the whale.

At maximum received levels ranging from 133 to 148 dB re 1µPa/√Hz, five out of six whales reacted to the signal designed to elicit a behavioral reaction. The reaction documented, however, was that the whales ceased feeding and came to the surface, which is not a desired effect given the purpose for the exposure was meant as an alert signal to prevent whale/ship interactions.

Impacts of Human Activity

Historic Whaling— Since right whales are considered large, slow-swimming whales and have a thick layer of blubber which results in their floating when killed, they were an easy and profitable species for early (pre-modern) whalers. It has been estimated that between 26,500 and 37,000 right whales were killed during the period from 1839 to 1909. From 1900 to 1999, a total of 742 North Pacific right whales were killed by whaling; of those, 331 were killed in the western North Pacific and 411 in the eastern north Pacific. This includes 372 whales killed illegally by the former U.S.S.R. in the period from 1963 to 1967, primarily in the GOA and Bering Sea (Angliss and Allen 2008).

Fisheries Interactions— Gillnets were implicated in the death of a right whale off the Kamchatka Peninsula (Russia) in October of 1989. No other incidental takes of right whales are known to have occurred in the North Pacific. Based on the available records, the estimated annual mortality rate incidental to U.S. commercial fisheries approaches zero whales per year from this stock. Therefore, the annual human-caused mortality level is considered to be insignificant and approaching a zero mortality and serious injury rate (Angliss and Outlaw 2006).

Ship Strikes— In the North Pacific, ship strikes and entanglements may pose a threat to right whales but information is lacking. Using what is known for the North Atlantic right whale, the species seems generally unresponsive to vessel sounds and given they are slow moving, they are susceptible to vessel collisions (Nowacek et al. 2004). In contrast to conditions for the North Atlantic right whale, however, ship strikes and entanglement impacts to the North Pacific right whale population may pose less of a threat because of their rare occurrence and scattered distribution in the GOA (NMFS 2007). Thus, the estimated annual rate of human-caused mortality and serious injury appears minimal (Angliss and Outlaw 2006).

4.2.5 Sei Whale (*Balaenoptera borealis*)

Stock—Eastern North Pacific

Regulatory Status— Sei whales (*Balaenoptera borealis*) are listed as endangered under the ESA. A species recovery plan has not been prepared. The ENP stock is considered a "depleted" and "strategic" stock under the MMPA

Habitat Preferences and Critical Habitat- Sei whales are most often found in deep, oceanic waters of the cool temperate zone. They appear to prefer regions of steep bathymetric relief, such as the continental shelf break, canyons, or basins situated between banks and ledges. These areas are often the location of persistent hydrographic features, which may be important factors in concentrating zooplankton, especially copepods. On the feeding grounds, the distribution is largely associated with oceanic frontal systems. In the north Pacific, sei whales are found feeding particularly along the cold eastern currents. Characteristics of preferred breeding grounds are unknown. In the north Pacific, sei whales particularly feed along the cold eastern currents. In the north Pacific, prey includes calanoid copepods, krill, fish, and squid. (DoN 2006). Critical habitat has not been designated for the ENP stock of sei whales.

Population Size and Trends— The IWC groups all sei whales in the North Pacific Ocean into one stock (Donovan 1991). Mark-recapture, catch distribution, and morphological research, however, indicated that more than one stock exists: one between 175°W and 155°W longitude, and another to the east of 155°W longitude (Masaki 1976, 1977). In the U.S. Pacific Exclusive Economic Zone (EEZ), only the ENP Stock is recognized. Worldwide, sei whales were severely depleted by commercial whaling activities. In the north Pacific, the pre-exploitation population estimate for sei whales is 42,000 whales, and the most current population estimate for sei whales in the entire north Pacific (from 1977) is 9,110 (NMFS 2006c).

Application of various models to whaling catch and effort data suggests that the total population of adult sei whales in the north Pacific declined from about 42,000 to 8,600 between 1963 and 1974 (Tillman 1977). Since 500 to 600 sei whales per year were killed off Japan from 1910 to the late 1950s, the stock size presumably was already, by 1963, below its carrying capacity level (Tillman 1977). Currently, the best estimate for the ENP stock is 43 (CV = 0.61) individuals (Carretta et al. 2007b). There are not sufficient numbers of individuals of this species present in the TMAA to allow for acoustic impact modeling, given they are few in number.

Distribution— Sei whales have a worldwide distribution and are currently found primarily in cold temperate north Pacific (north of 40°N) to subpolar latitudes (as far south as 20°N), rather than in the tropics or near the poles. Sei whales range as far south as Baja California, Mexico, Hawaii, and Guam in the Northern Marianas Islands. Whaling data suggest that the northern limit for this species was about 55°N. Sei whales are usually observed singly or in small groups of 2 to 5 animals, but are occasionally found in larger (30 to 50) loose aggregations (DoN 2006).

Sei whales are also known for occasional irruptive occurrences in areas followed by disappearances for sometimes decades. Currently in the Alaskan waters, sei whales are thought to occur mainly south of the Aleutian Islands. Whaling records from the 1900s indicate there were high densities of sei whales in the northwestern and northeastern portions (i.e., near Portlock Bank) of the GOA during May through August. (DoN 2006) There were no sei whales detected during the April 2009 survey of the TMAA (although there were sightings of 38 unidentified large whales; Rone et al. 2009).

Life History— In the North Pacific, sei whales particularly feed along the cold eastern currents (Perry et al. 1999). In the North Pacific, prey includes calanoid copepods, krill, fish, and squid (Nemoto and Kawamura 1977). The dominant food for sei whales off California during June through August is the northern anchovy, while in September and October they eat mainly krill (Rice 1977). The location of winter breeding areas and characteristics of preferred breeding grounds are unknown (Rice 1998, Perry et al. 1999).

Reproduction/Breeding— No breeding areas have been determined but calving is thought to occur from September to March (Rice 1977) and sei whales likely move south for breeding/calving. Their reproductive cycle is about 2 years (Gambell 1985). There are no known areas used by sei whales for reproduction or calving in the TMAA.

Diving Behavior— There are no reported diving depths or durations for sei whales. Sei whales are capable of diving 5 to 20 min to opportunistically feed on plankton (e.g., copepods and krill), small schooling fish, and cephalopods (e.g., squid) by both gulping and skimming. (DoN 2006)

Acoustics— Sei whale vocalizations have been recorded on a few occasions. In the North Atlantic off Canada, recorded sounds from sei whales consisted of 10 to 20 short duration frequency-modulated sweeps between 1.5 and 3.5 kHz; source level unknown (Richardson et al. 1995). Sei whales were also recorded in the Antarctic having produced broadband "growls" and "whooshes" at an average frequency of 433 Hz (see Table 3.8-3) and source level of approximately 156 dB re 1 µPa @ 1 m (McDonald et al. 2005). While no data on hearing ability for this species are available, it has been hypothesized that mysticetes have acute infrasonic hearing (DoN 2006).

Impact of Human Activity

Historic Whaling— Several hundred sei whales in the North Pacific were taken each year by whalers based at shore stations in Japan and Korea between 1910 and the start of World War II (Committee for Whaling Statistics 1942). Small numbers were taken sporadically at shore stations in British Columbia from the early 1900s until the 1950s, when their importance began to increase (Pike and MacAskie 1969). More than 2,000 were killed in British Columbia waters between 1962 and 1967, when the last whaling station in western Canada closed (Pike and MacAskie 1969). Small numbers were taken by shore whalers in Washington (Scheffer and Slipp 1948) and California (Clapham et al. 1997) in the early 20th century, and California shore whalers took 386 from 1957 to 1971 (Rice 1977). Perry et al. (1999) reports that from 1910 to 1975, approximately 74,215 sei whales were caught in the entire North Pacific Ocean. Tillman (1977) reported that heavy exploitation by pelagic whalers began in the early 1960s, with total catches throughout the North Pacific averaging 3,643 per year from 1963 to 1974 (total 43,719; annual range 1,280-6,053), while Barlow et al. (1997) reported the capture of sei whales in the North Pacific was 61,500 between 1947 and 1987.

A major area of discussion in recent years has been IWC member nations issuing permits to kill whales for scientific purposes. Since the moratorium on commercial whaling came into effect Japan, Norway, and Iceland have issued scientific permits as part of their research programs. For the last 5 years, only Japan has issued permits to harvest sei whales although Iceland asked for a proposal to be reviewed by the IWC Scientific Committee in 2003. The Government of Japan has issued scientific permits in recent years to capture minke, Bryde's, and sperm whales in the North Pacific, known as JARPA II and JARPN II programmes. The Government of Japan extended the captures to include 50 sei whales from pelagic areas of the western North Pacific. (Carretta et al. 2007)

Fisheries Interactions— Sei whales, because of their offshore distribution and relative scarcity in U.S. Atlantic and Pacific waters, probably have a lower incidence of entrapment and entanglement than fin whales. Data on entanglement and entrapment in non-U.S. waters are not reported systematically. Heyning and Lewis (1990) made a crude estimate of about 73 rorquals killed/year in the southern California offshore drift gillnet fishery during the 1980s. Some of these may have been fin whales instead of sei whales. Some balaenopterids, particularly fin whales, may also be taken in the drift gillnet fisheries for sharks and swordfish along the Pacific coast of Baja California, Mexico (Barlow et al. 1997). Heyning and Lewis (1990) suggested that most whales killed by offshore fishing gear do not drift far enough to strand on beaches or to be detected floating in the nearshore corridor where most whale-watching and other types of boat traffic occur. Thus, the small amount of documentation may not mean that entanglement in fishing gear is an insignificant cause of mortality. Observer coverage in the Pacific offshore fisheries has been too low for any confident assessment of species-specific entanglement rates (Barlow et al. 1997). The offshore drift gillnet fishery is the only fishery that is likely to take sei whales from this stock, but no fishery mortalities or serious injuries to sei whales have been observed. Sei whales, like other large whales, may break through or carry away fishing gear. Whales carrying gear may die later, become debilitated or seriously injured, or have normal functions impaired, but with no evidence recorded.

Ship Strikes— The decomposing carcass of a sei whale was found on the bow of a container ship in Boston harbor, suggesting that sei whales, like fin whales, are killed at least occasionally by ship strikes

(Waring et al. 1997). Sei whales are observed from whale-watching vessels in eastern North America only occasionally (Edds et al. 1984) or in years when exceptional foraging conditions arise (Weinrich et al. 1986, Schilling et al. 1992). There is no comparable evidence available for evaluating the possibility that sei whales experience significant disturbance from vessel traffic. During 2000-2004, there were an additional five injuries and three mortalities of unidentified large whales attributed to ship strikes. Additional mortality from ship strikes probably goes unreported because the whales do not strand or, if they do, they do not always have obvious signs of trauma. (DoN 2006)

Other Threats— No major habitat concerns have been identified for sei whales in either the North Atlantic or the North Pacific. Sei whales have a preference for copepods and euphausiids (i.e., low trophic level organisms), and may be less susceptible to the bioaccumulation of organochlorine and metal contaminants than, fin, humpback, and minke whales, all of which seem to feed more regularly on fish and euphausiids (O'Shea and Brownell 1994). Sei whales off California often feed on pelagic fish as well as invertebrates (Rice 1977). There is no evidence that levels of organochlorines, organotins, or heavy metals in baleen whales generally (including fin and sei whales) are high enough to cause toxic or other damaging effects (O'Shea and Brownell 1994). However, very little is known about the possible long-term and trans-generational effects of exposure to pollutants.

4.2.6 Sperm Whale (*Physeter macrocephalus*)

Stock—North Pacific

Regulatory Status— Sperm whales (*Physeter macrocephalus*) are listed as endangered under the ESA and designated as depleted under MMPA. The North Pacific stock is classified as strategic. A draft species recovery plan has been prepared (NMFS 2006a).

Habitat Preferences and Critical Habitat- Sperm whales show a strong preference for deep waters (Rice 1989), especially in areas with high sea floor relief. Recent research at the Azores Seamounts off Portugal did not, however, demonstrate association of sperm whales with seamounts (Morato et al. 2008). Globally, sperm whale distribution is associated with waters over the continental shelf break, over the continental slope, and into deeper waters (Hain et al. 1985). However, in some areas, such as off New England, on the southwestern and eastern Scotian Shelf, or the northern Gulf of California, adult males are reported to use waters with bottom depths less than 328 ft (100 m) and as shallow as 131 ft (40 m) (Whitehead et al. 1992, Scott and Sadove 1997, Croll et al. 1999, Garrigue and Greaves 2001, Waring et al. 2002). Worldwide, females rarely enter the shallow waters over the continental shelf (Whitehead 2003). In GOA the primary occurrence for the sperm whales is seaward of the 1640 ft (500 m) isobath (DoN 2006).

Sperm whales have a highly diverse diet. Prey includes large mesopelagic squid and other cephalopods, fish, and occasionally benthic invertebrates (Fiscus and Rice 1974, Rice 1989, Clarke 1996).

Critical habitat has not been designated for sperm whales.

Population Size and Trends— Current estimates of population abundance, status, and trends for the North Pacific stock in Alaska of sperm whales are not available. For the North Pacific, sperm whales have been divided into three separate stocks based on where they are found, designated as (1) Alaska (North Pacific stock), (2) California/Oregon/Washington, and (3) Hawaii. (Angliss and Allen 2008)

Estimates of pre-whaling abundance in the North Pacific are considered somewhat unreliable, but sperm whales may have totaled 1,260,000 individuals (Angliss and Allen 2008). Approximately 258,000 sperm whales in the North Pacific were harvested by commercial whalers between 1947 and 1987 (Hill and DeMaster 1999). However, this number may be negatively biased by as much as 60 percent because of under-reporting by Soviet whalers (Brownell et al. 1998). In particular, the Bering Sea population of sperm whales (consisting mostly of males) was severely depleted (Perry et al. 1999). Catches in the north Pacific continued to climb until 1968, when 16,357 sperm whales were harvested. Catches declined after 1968, in part through limits imposed by the IWC (Rice 1989).

The following has been estimated for other stocks in the Pacific:

• California/Oregon/Washington	2,853 (CV = 0.25); Carretta et al. (2008)
• Hawaii	7,082 (CV = 0.30); Carretta et al. (2008)
• North Pacific	102,112 (CV = 0.15); Angliss and Allen (2008)

From 26 June to 15 July 2003, a survey in the Shelikof Strait (north of Kodiak), Cook Inlet, Prince William Sound and between Kodiak and Montague Island detected six sperm whales along the shelf break, with an average group size of 1.2 (Waite 2003). Data from this survey yielded a density of 0.0003/km^2, which is applicable year-round for sperm whales in the TMAA as described in detail in Appendix B. This density was based on only two "on effect" sightings, so confidence in the value is low, but it is the only data from which to derive a density that exists at this time for the region. The April 2009 survey in the TMAA recorded sperm whales acoustically in both the inshore and offshore strata but no sperm whales were detected visually (Rone et al. 2009).

Distribution— Sperm whales occur throughout all ocean basins from equatorial to polar waters, including the entire North Atlantic, North Pacific, northern Indian Ocean, and the southern oceans. Sperm whales are found throughout the North Pacific and are distributed broadly from tropical and temperate waters to the Bering Sea as far north as Cape Navarin. Male sperm whales are found from tropical to polar waters in all oceans of the world, between approximately 70°N and 70°S (Rice 1998). In the North Pacific, the distribution of females and young sperm whales is more limited year-round and generally corresponds to tropical and temperate waters approximately to 50°N latitude (at least 6 degrees south of the TMAA; Whitehead 2003). Summer surveys in the coastal waters around the central and western Aleutian Islands have found sperm whales to be the most frequently sighted large cetacean (Angliss and Allen 2008). Acoustic surveys have detected the presence of sperm whales year-round in the GOA although about twice as many are present in summer as in winter (Mellinger et al. 2004, Moore et al. 2006). Fewer detections in winter are reflected by the documented seasonal movement of whales from Canada and Japan to the GOA/Bering Sea/Aleutian Islands region (Angliss and Allen 2008).

Life History Information— Female sperm whales become sexually mature at about 9 years of age (Kasuya 1991). Male sperm whales take between 9 and 20 years to become sexually mature, but will require another 10 years to become large enough to successfully compete for breeding rights (Kasuya 1991). The age distribution of the sperm whale population is unknown, but sperm whales are believed to live at least 60 years (Rice 1978). Estimated annual mortality rates of sperm whales are thought to vary by age, but previous estimates of mortality rate for juveniles and adults are now considered unreliable (International Whaling Commission 1980).

Reproduction/Breeding— Calving generally occurs in the summer at lower latitudes and the tropics (DoN 2005). Adult females give birth after about 15 months gestation and nurse their calves for 2 to 3 years. The calving interval is estimated to be about 4 to 6 years (Kasuya 1991). There are no known areas used by sperm whales for reproduction or calving in the TMAA.

Diving Behavior— Details regarding the relatively extensive dive behavior information for sperm whales are presented in Appendix B. In general, sperm whales forage during deep dives that routinely exceed a depth of 1,312 ft (400 m) and 30 min duration (Watkins et al. 2002). Sperm whales can dive to depths of over 6,562 ft (2,000 m) with durations of over 60 min (Watkins et al. 1993). Sperm whales spend up to 83 percent of daylight hours underwater (Jaquet et al. 2000, Amano and Yoshioka 2003). Males do not spend extensive periods at the surface (Jaquet et al. 2000). In contrast, females spend prolonged periods at the surface (1 to 5 hours daily) without foraging (Whitehead and Weilgart 1991, Amano and Yoshioka 2003). The average swimming speed is estimated to be 2.3 ft/sec (0.7 m/sec) (Watkins et al. 2002). Dive descents averaged 11 min at a rate of 5.0 ft/sec (1.52 m/sec), and ascents averaged 11.8 min at a rate of 4.6 ft/sec (1.4 m/sec) (Watkins et al. 2002).

Acoustics— Sperm whales produce short-duration (generally less than 3 sec), broadband clicks. These clicks range in frequency from 100 Hz to 30 kHz (Weilgart and Whitehead, 1993, 1997; Goold and Jones 1995; Thode et al. 2002), with dominant energy in two bands (2 to 4 kHz and 10 to 16 kHz). The source levels can be up to 236 dB re 1 µPa @ 1 m (Møhl et al. 2003). Thode et al. (2002) suggested that the acoustic directivity (angular beam pattern) from sperm whales must range between 10 and 30 dB in the 5- to 20-kHz region. The clicks of neonate sperm whales are very different from the usual clicks of adults, in that they are of low directionality, long duration, and low frequency (centroid frequency between 300 and 1,700 Hz) with estimated source levels between 140 and 162 dB re 1 µPa @ 1 m (Madsen et al. 2003). Clicks are heard most frequently when sperm whales are engaged in diving and foraging behavior (Whitehead and Weilgart 1991, Miller et al. 2004, Zimmer et al. 2005). These may be echolocation clicks used in feeding, contact calls (for communication), and orientation during dives. When sperm whales socialize, they tend to repeat series of clicks (codas), which follow a precise rhythm and may last for hours (Watkins and Schevill 1977). Codas are shared between individuals of a social unit, and are considered to be primarily for intragroup communication (Weilgart and Whitehead 1997, Rendell and Whitehead 2004).

The anatomy of the sperm whale's ear indicates that it hears high-frequency sounds (Ketten 1992). Anatomical studies also suggest that sperm whales have some ultrasonic hearing, but at a lower maximum frequency than many other odontocetes (Ketten 1992). Sperm whales may also possess better low-frequency hearing than some other odontocetes, although not as extraordinarily low as many baleen whales (Ketten 1992). Auditory brainstem response in a neonatal sperm whale indicated highest sensitivity to frequencies between 5 and 20 kHz (Ridgway and Carder 2001).

Impacts of Human Activity

Historic Whaling— In 2000, the Japanese Whaling Association announced that it planned to kill 10 sperm whales and harvest 5 sperm whales. Japanese whalers took another 31 sperm whales between 2001 and 2005 (Angliss and Allen 2008). The consequence of these deaths on the status and trend of sperm whales remains uncertain, given the lack of information concerning sperm whale abundance. (Institute of Cetacean Research undated)

Fisheries Interactions— In U.S. waters in the Pacific, sperm whales have been incidentally taken only in drift gillnet operations, which killed or seriously injured an average of nine sperm whales per year from 1991-1995 (Barlow et al. 1997). Of the eight sperm whales taken by the California/Oregon drift gillnet fishery, three were released alive and uninjured (37.5 percent), one was released injured (12.5 percent), and four (50 percent) were killed (NMFS 2000). Therefore, approximately 63 percent of captured sperm whales could be killed accidentally or injured, based on the mortality and injury rate of sperm whales observed taken by the U.S. fleet from 1990 to 2000. Based on past fishery performance, sperm whales were not observed taken in every year; they were observed to be taken in 4 out of 10 years (NMFS 2000). During the 3 years the Pacific Coast Take Reduction Plan has been in place, a sperm whale was taken only once, in a set that did not comply with the Take Reduction Plan (NMFS 2000).

Interactions between sperm whales and longline fisheries in the GOA have been reported since 1995 and are increasing in frequency (Rice 1989, Hill and Mitchell 1998, Hill and DeMaster 1999). Between 2002 and 2006, there were three observed serious injuries (considered mortalities) to sperm whales in the GOA from the sablefish longline fishery (Angliss and Allen 2008). Sperm whales have also been observed in GOA feeding off longline gear (for sablefish and halibut) at 38 of the surveyed stations (Angliss and

Allen 2008). Recent findings suggest sperm whales in Alaska may have learned that fishing vessel propeller cavitations (as gear is retrieved) are an indicator that longline gear with fish is present as a predation opportunity (Thode et al. 2007).

Berzin (1972) noted that there were "many" reports of sperm whales of different age classes being struck by vessels, including passenger ships and tug boats. Sperm whales spend long periods (typically up to 10 min) at the surface between deep dives (Jacquet et al. 1998). This behavior could make sperm whales more vulnerable to ship strikes. There is record of one collision between a fishing vessel and a sperm whale within the TMAA (Gabriele et al., manuscript on file).

4.2.7 Steller Sea Lion (*Eumetopias jubatus*)

The Steller sea lion's (*Eumetopias jubatus*) range includes portions of the TMAA. The boundary between the Western U.S stock and the Eastern U.S. stock approximately bisects the TMAA, although the TMAA is located offshore of the main habitat/foraging areas.

Stock—Eastern and Western United States

Regulatory Status— In 1997, NMFS reclassified Steller sea lions into two distinct subpopulations, based on genetics and population trends (Loughlin 1997, Angliss and Outlaw 2005). The Western U.S. stock was designated as endangered and includes animals at and west of Cape Suckling, Alaska (144°W; NMFS 1997c). The Eastern U.S. stock remained designated as threatened and includes animals east of Cape Suckling (NMFS 1997c, Loughlin 2002, Angliss and Outlaw 2005) that extend into southeastern Alaska, and Canada. Rookeries of the Eastern U.S. stock occur along the coasts of Oregon and California (NMFS 2008c). The Steller sea lion is designated as depleted under MMPA. A final revised species recovery plan addresses both the Eastern U.S. and Western U.S. stocks (NMFS 2008c).

Habitat Preferences and Critical Habitat- Steller sea lions are opportunistic predators, feeding primarily on fishes (including walleye pollock, cod, mackerel, and herring), invertebrates, and cephalopods (octopus and squid), with diet varying geographically and seasonally (Merrick et al. 1997, Loughlin 2002, DoN 2006). For the GOA, foraging habitat is primarily shallow, nearshore and continental shelf waters 8 to 24 km (4.3 to 13 nm) offshore with a secondary occurrence inshore of the 1,000 m isobath, and a rare occurrence seaward of the 1,000 m isobath.

Steller sea lions form large rookeries during late spring when adult males arrive and establish territories (Pitcher and Calkins 1981), so the rookeries would normally be occupied during the likely time-period for the annual Northern Edge exercise.

In 1993, NMFS published a final rule to designate critical habitat for Steller sea lions (NMFS 2008). There is no Critical Habitat for Steller sea lions in the TMAA. The areas designated as critical habitat were based on land use patterns, the extent of foraging trips, and the availability of prey items with particular importance given to the haul out areas where animals rest, pup, nurse, mate, and molt. Two kinds of marine habitat were designated as critical: "aquatic zones" around rookeries and haulouts and three special aquatic feeding areas in Alaska. The special aquatic foraging areas were chosen, "based on 1) at-sea observations indicating that sea lions commonly used these areas for foraging, 2) records of animals killed incidentally in fisheries in the 1980s, 3) knowledge of sea lion prey and their life histories and distributions, and 4) foraging studies" (NMFS 2008).

For the Eastern U.S. stock, the Critical Habitat aquatic zones (located east of 144°W longitude) extend 3,000 ft (0.9 km) seaward in state and federally managed waters from the baseline or basepoint of each major rookery. None of this Critical Habitat is in the vicinity of the TMAA.

For the Western U.S. stock, Critical Habitat for aquatic zones located (west of 144°W longitude) extend 20 nm (37 km) seaward in state and federally managed waters. None of the aquatic zones are located within the boundaries of the TMAA. Critical Habitat for the Western U.S. stock in the vicinity of the TMAA is depicted in Figure 4-2 (NMFS 2008).

Population Size and Trends— The minimum abundance estimate for Western U.S. stock Steller sea lions is 38,988 individuals, and the Eastern stock is estimated at 45,095 to 55,832 (Angliss and Allen 2008). Given the wide dispersal of individuals, both the Western U.S. and Eastern U.S. stock may occur in the GOA (DoN 2006, Angliss and Outlaw 2007, NMFS 2008), with about 70 percent of the population living in Alaskan waters. Between 2000 and 2004, the Western U.S. stock increased at a rate of approximately 3 percent per year (Fritz and Stinchcomb 2005). The Eastern U.S. stock has increased at an annual rate of approximately 3 percent since at least the late 1970s (Pitcher et al. 2007) and may be a candidate for removal from the list of threatened and endangered species (NMFS 2008). Despite incomplete surveys conducted in 2006 and 2007, the available data indicate that the western Steller sea lion population (non-pups) was stable since 2004 (when the last complete assessment was done). The revised Steller Sea Lion Recovery Plan (NMFS 2008) contains recovery criteria to change the listing of the Western U.S. stock from endangered to threatened (“down-listing”) and to remove it from the list of species requiring ESA protection (delist).

For purposes of acoustic impact modeling, a density of 0.0098/km^2 was derived for Steller sea lions in the TMAA as described in detail in Appendix B.

Distribution— Steller sea lions do not migrate, but they often disperse widely outside of the breeding season (Loughlin 2002). Steller sea lions are gregarious animals that often travel or haul out in large groups of up to 45 individuals (Keple 2002). At sea, groups usually consist of females and subadult males; adult males are usually solitary while at sea (Loughlin 2002). An area of high occurrence extends from the shore to the 273-fathom (500-m) depth. For the GOA, foraging habitat is primarily shallow, nearshore, and continental shelf waters 4.3 to 13 nm (8 to 24 km) offshore with a secondary occurrence inshore of the 3,280 ft (1,000 m) isobath, and a rare occurrence seaward of the 3,280 ft (1,000 m) isobath. Steller sea lions have been sighted foraging in the middle of the GOA (DoN 2006). The April 2009 survey in the TMAA encountered two groups of Steller sea lions (Rone et al. 2009).

Life History— Foraging habitat is primarily shallow, nearshore and continental shelf waters, and some Steller sea lions feed in freshwater rivers (Reeves et al. 1992, Robson 2002). They also are known to feed in deep waters past the continental shelf break (DoN 2006). Haulout and rookery sites are located on isolated islands, rocky shorelines, and jetties. Steller sea lions are opportunistic predators, feeding primarily on fish and cephalopods, and their diet varies geographically and seasonally (Merrick et al. 1997). They feed near land or in relatively shallow water (Pitcher and Calkins 1981).

Steller sea lions form large rookeries during late spring when adult males arrive and establish territories. Large males aggressively defend territories while non-breeding males remain at peripheral sites or haulouts. Females arrive soon after and give birth to pups. Females reach sexual maturity at 4 to 5 years of age. (Pitcher and Calkins 1981)

Natural mortality in Steller sea lions is thought to result primarily from killer whale predation, diseases and parasites, and habitat loss (National Marine Fisheries Service 2008b). The carrying capacity of the North Pacific for Steller sea lions also likely fluctuates in response to changes in the environment.

Reproduction/Breeding— Most births occur from mid-May through mid-July at rookeries outside the boundaries of the MAA, and breeding takes place shortly thereafter (Pitcher and Calkins 1981). Rookeries of the Eastern stock occur along the coasts of Oregon and California (National Marine Fisheries Service 2008c). There are no known areas used by Steller sea lions for reproduction or calving in the TMAA.

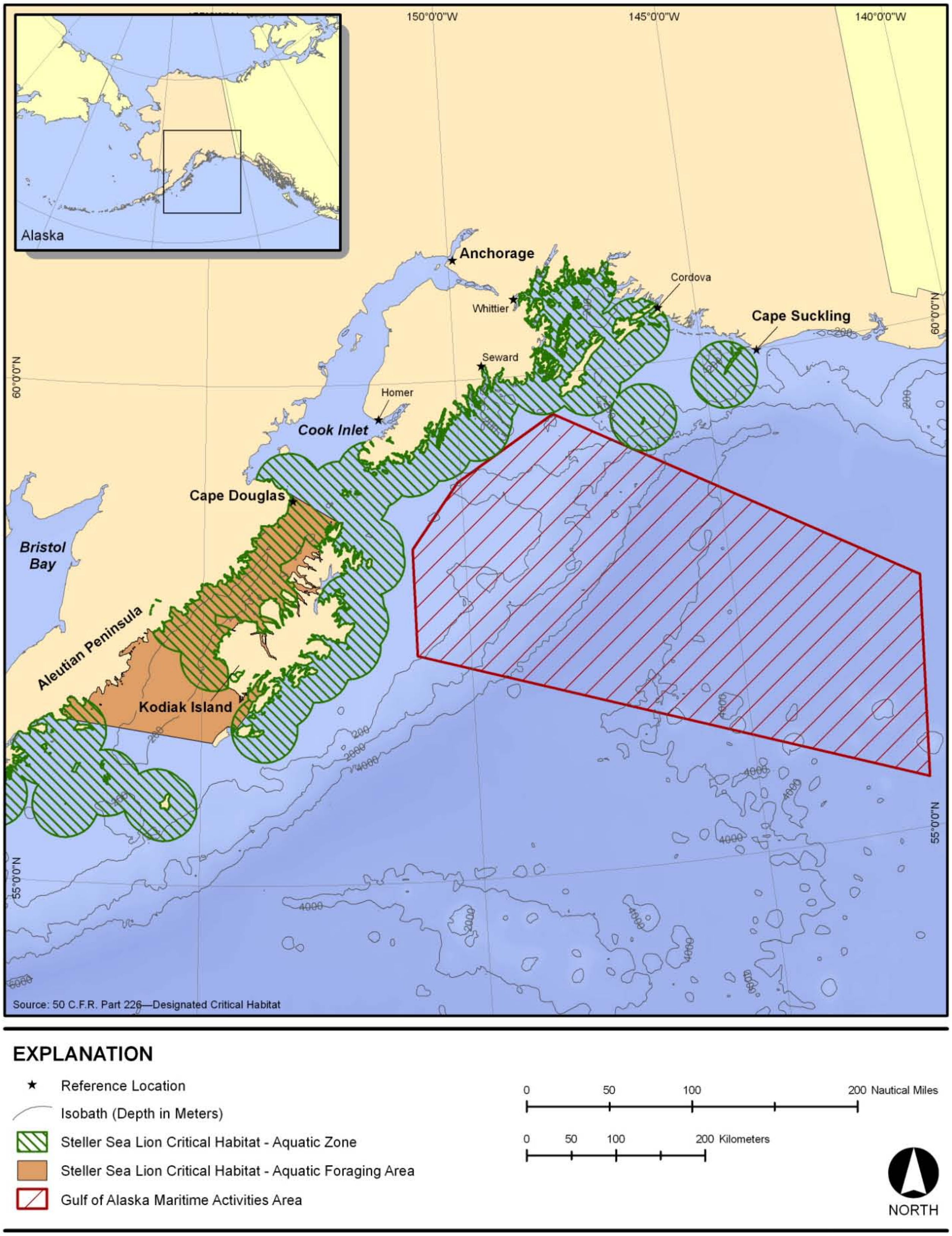

Figure 4-2. Steller Sea Lion Western U.S. Stock Critical Habitat in the Vicinity of the TMAA

Diving Behavior— Details regarding the characterization of diving behavior for input into acoustic impact modeling for Steller sea lions are provided in Appendix B. Diving and foraging activity varies by sex, age, and season. During the breeding season, females with pups feed mostly at night, while territorial males eat little or no food (Loughlin 2002). In the winter, females make long trips of around 81 mi (130 km) and dive deeply to locate prey (Merrick and Loughlin 1997, Loughlin 2002). In the summer, trip length is about 11 mi (17 km) and dives are shallower (Loughlin 2002). Females usually go to sea to feed and return to nurse their pups in 24- to 48-hour cycles (NRC 2003). Steller sea lions tend to make shallow dives of less than 820 ft (250 m) but are capable of deeper dives (NMFS 2003).

Acoustics— On land, territorial male Steller sea lions usually produce low frequency roars (Schusterman et al. 1970, Loughlin et al. 1987). The calls of females range from 30 Hz to 3 kHz (see Table 3.8-3), with peak frequencies from 150 Hz to 1 kHz; typical duration is 1.0 to 1.5 sec (Campbell et al. 2002). Pups produce bleating sounds. Underwater sounds are similar to those produced on land (Loughlin et al. 1987).

When the underwater hearing sensitivity of two Steller sea lions was tested, the hearing threshold of the male was significantly different from than that of the female. The range of best hearing for the male was from 1 to 16 kHz, with maximum sensitivity (77 dB re 1 µPa @ 1 m) at 1 kHz. The range of best hearing for the female was from 16 kHz to above 25 kHz, with maximum sensitivity (73 dB re 1 µPa @ 1 m) at 25 kHz. However, because of the small number of animals tested, the findings could not be attributed to individual differences in sensitivity or sexual dimorphism (Kastelein et al. 2005).

Impacts of Human Activity

Major sources of induced (anthropogenic) mortality include harvesting by Alaska Natives, fisheries interactions (e.g., entanglements) and food shortages as a result of fishing pressure on prey items, and environmental contamination (NMFS 2008).

Hunting— Historically, the Eastern U.S. stock was subjected to substantial mortality by humans, primarily due to commercial exploitation and both sanctioned and unsanctioned predator control (NMFS 2008c). Alaska Natives are exempted from the MMPA and ESA and continue taking seals for subsistence and/or handicraft purposes. The mean annual harvest of Steller sea lions by Alaska Natives between 2000 and 2004 was estimated approximately 190 animals with the majority of these harvests having involved the Western U.S. stock (NMFS 2000). The mean annual take for subsistence harvest between 2002 and 2006 is estimated to have been 198 animals in the Western U.S. stock (Angliss and Allen 2008).

State-sanctioned commercial harvest of Steller sea lions ended in 1972 with the advent of the MMPA. Although not well documented, there is little doubt that numbers of Steller sea lions were greatly reduced in many locations by these activities (NMFS 2008c). Commercial hunting and predator control activities have been discontinued and no longer affect the Eastern U.S. stock. In contrast to the Western U.S. stock, which is experiencing potential human-related threats from competition with fisheries (potentially high), incidental take by fisheries (low), and toxic substances (medium) no threats to continued recovery were identified for the Eastern U.S. stock. Although several factors affecting the Western U.S. stock also affect the Eastern U.S. stock (e.g., environmental variability, killer whale predation, toxic substances, disturbance, shooting), these threats do not appear to be at a level sufficient to keep the Eastern U.S. stock from continuing to recover, given the long-term sustained growth of the population as a whole (NMFS 2008c).

Fisheries Interactions— Lethal deterrence of seals from fishing activities ended in 1990 when Steller sea lions were listed under the ESA. Incidental take by fisheries has been assessed as having a low potential threat for the Western U.S. stock with an estimated approximate 30 lethal entanglements annually and 3.6 lethal entanglements (estimated in 2005) for the Eastern U.S. stock (NMFS 2008, Angliss and Allen 2008). Entanglement in marine debris is assessed as a minor threat to the Steller sea lions (NMFS 2008).

Both climate shift and fisheries induced changes in prey communities may have affected the condition of Steller sea lions over the last 40 years, but the relative importance of each is a matter of considerable debate (NMFS 2008c). There are two fishery-related theories about what may have contributed most to decline of Steller sea lions through reductions in prey biomass and quality, which resulted in nutritional stress (proximate cause) and subsequent decreases in vital rates (Trites et al. 2006a). In one case, nutritional stress stems from climate-induced changes in the species composition, distribution or nutritional quality of the sea lion prey base. In the other, fishery-induced reductions in localized or overall prey abundance cause nutritional stress (Braham et al. 1980; NMFS 1998a, 2000).

What may have been unusual about the decline in sea lions observed through 2000 is the introduction of large-scale commercial fisheries on sea lion prey. While large-scale groundfish fisheries began in the 1960s, their potential for competitive overlap with Steller sea lions (e.g., catches within what would be designated as critical habitat) increased markedly in the 1980s. Overall and localized fisheries removals of prey could have exacerbated natural changes in carrying capacity, possibly in nonlinear and unpredictable ways (Goodman et al. 2002). Reductions in carrying capacity may have contributed to declines in Steller sea lion fatality that are believed to have occurred at some rookeries through at least 2002 despite shifts to potentially more favorable environmental conditions that may have occurred in 1989 and 1998 (NMFS 2008c).

4.3 NON-ESA CETACEAN SPECIES

4.3.1 Baird's Beaked Whale (*Berardius bairdii*)

Stock—Alaska

Regulatory Status— Baird's beaked whales (*Berardius bairdii*) are not listed as threatened or endangered under the ESA or depleted under the MMPA. The Alaska stock of Baird's beaked whales is not classified as strategic.

Habitat Preferences- Baird's beaked whales appear to occur mainly in cold deep waters (3,300 ft [1,000 m] or greater) over the continental slope, oceanic seamounts, and in areas with submarine escarpments. They may also occur occasionally near shore along narrow continental shelves. The range for the Alaska stock of Baird's beaked whale extends from Cape Navarin (63°N) and the central Sea of Okhotsk (57°N) to St. Matthew Island, the Pribilof Islands in the Bering Sea, and the northern GOA. (Angliss and Allen 2008, DoN 2006)

Population Size and Trends— There is no reliable population estimate for the Alaska stock of Baird's beaked whale (Angliss and Allen 2008). For purposes of acoustic impact modeling, a density of 0.0005/km^2 was derived for Baird's beaked whales in the TMAA as described in detail in Appendix B.

Distribution— Baird's beaked whales are found only in the North Pacific and the adjacent seas (Bering Sea, Okhotsk Sea, Sea of Japan, and the Gulf of California), mainly north of 34°N in the west and 28°N in the east. The best-known populations occur in the coastal waters around Japan since whaling takes place there. Along the U.S. west coast, Baird's beaked whales are seen primarily along the continental slope from late spring to early fall. British Columbia whalers commented that Baird's beaked whales were most often sighted during May through September, with most catches occurring during August. Baird's beaked whales are seen less frequently and are presumed to be further offshore during the colder water months of November through April. (DoN 2006)

Within the GOA, the area of primary occurrence for Baird's beaked whales during both summer and winter is between the depths of 1,640 and 9,842 ft (500 and 3,000 m). There is no evidence of seasonal movements by this species that would affect these predicted occurrence patterns. There is a secondary occurrence between the 656 and 1,640 ft (200 and 500 m) isobaths, as well as seaward of the 9,842 ft (3,000 m) isobath. There is a rare occurrence in waters shallower than the 656 ft (200 m) isobath. In 2003, Waite (2003) reported a group of four Baird's beaked whales was sighted at the shelf break to the east of the TMAA. There were no beaked whales detected acoustically or visually (although two groups of unidentified small whale were sighted) during the April 2009 survey of the TMAA (Rone et al. 2009).

Life History— Baird's beaked whales occur in relatively large groups of 6 to 30, and groups of 50 or more sometimes are seen (Balcomb 1989). Baird's beaked whales in Japan prey primarily on deepwater gadiform fishes and cephalopods, indicating that they feed primarily at depths ranging from 800 to 1,200 m (Walker et al. 2002, Ohizumi et al. 2003). Sexual maturity occurs at about 8 to 10 years, and the calving peak is in March and April (Balcomb 1989).

Reproduction/Breeding— Mating generally occurs in October and November but little else is known of their reproductive behavior (Balcomb 1989). There are no known areas used by Baird's beaked whales for reproduction or calving in the TMAA.

Diving Behavior— Details regarding the characterization of diving behavior for input into acoustic impact modeling for Baird's beaked whales is provided in Appendix B. Analysis of stomach contents from captured and stranded individuals suggests that beaked whales are deep-diving animals, feeding by suction (Heyning and Mead 1996). The overall dive behavior of Baird's beaked whales is not known; therefore the diving behavior of a related species, Blainville's beaked whale, is used to provide diving behavior information. Baird et al. (2006) reported on the diving behavior of four Blainville's beaked whales (a similar species) off the west coast of Hawaii. The Blainville's beaked whales foraged in deep ocean areas (2,270-9,855 ft [691-3,003 m]) with a maximum dive to 4,619 ft (1,407 m). Dives ranged from at least 13 min (lost dive recorder during the dive) to a maximum of 68 min (Baird et al. 2006).

Acoustics— Sounds recorded from beaked whales are divided into two categories: whistles and pulsed sounds (clicks), with whistles likely serving a communicative function, and pulsed sounds being important in foraging and/or navigation (Johnson et al. 2004, Madsen et al. 2005, MacLeod and D'Amico 2006). Both whistles and clicks have been recorded from Baird's beaked whales in the eastern north Pacific. Whistles had fundamental frequencies between 4 and 8 kHz, with two to three strong harmonics within the recording bandwidth. Clicks had a dominant frequency around 23 kHz, with a second frequency peak at around 42 kHz (see Table 3.8-3) and, unlike species that echolocate, were most often emitted in irregular series of very few clicks. (DoN 2006)

There is no information on the hearing abilities of Baird's beaked whale. In fact, there is no direct information available on the exact hearing abilities of most beaked whales, except for recent information from a live stranded juvenile Gervais' beaked whales (*Mesoplodon europaeus*); another whale in the same taxonomic family. Auditory evoked potential tests on this beaked whale found its hearing to be most sensitive to high-frequency signals between 40 and 80 kHz but it also perceiving mid-frequency sound down to 5 kHz although resulting in smaller evoked potentials (Cook et al. 2006).

It has been previously postulated, based on the occurrence of beaked whale strandings associated with ASW training events, that the species in general may be more sensitive than other cetaceans to sonar (Southall et al. 2007). In contrast and based on recent field experiments with tagged beaked whales, it has been suggested that beaked whales may be "particularly sensitive to anthropogenic sounds, but there is no evidence that they have a special sensitivity to sonar compared with other signals" (Tyack 2009). These beaked whales' reactions to three different sound stimulus consisted of the animals stopping their clicking, producing fewer foraging buzzes than normal, and ending their dives in a long and unusually slow ascent while moving away from the sound source (Tyack 2009).

Impacts of Human Activity

While beaked whale strandings have been reported since the 1800s, several mass strandings since have been associated with naval operations that may have included mid-frequency sonar (Cox et al. 2006). As Cox et al. (2006) concluded, the state of science can not yet determine if a sound source such as mid-frequency sonar alone causes beaked whale strandings, or if other factors (acoustic, biological, or environmental) must co-occur in conjunction with a sound source. Recent evidence from the experimental sonar exposure to tagged beaked whales seems to suggest there is no general beaked whale sensitivity to Navy sonar (Tyack 2009).

For Alaska waters this is important given that between 27 June and 19 July 2004, five beaked whales were discovered stranded at various locations along 1,600 mi (2,625 km) of the Alaskan coastline and one was found floating (dead) at sea; These whales included three Baird's beaked whales. As described in Appendix A in greater detail, questions were raised soon after the strandings as to whether they were the result of Navy sonar use, although sonar training events had not been part of an exercise which took place in that general timeframe. While records of Baird's beaked whale strandings are uncommon in Alaska waters, they are not unknown. Between 1975 and 1987, eight Baird's beaked whales were found stranded as far north as the area between Cape Pierce and Cape Newenham, to the east near Kodiak, and along the Aleutian Islands (Zimmerman, 1991). In Alaska there has been on average, including more recent data, between zero and three beaked whale strandings documented per year (Jensen 2008).

4.3.2 Cuvier's Beaked Whale (*Ziphius cavirostris*)

Stock—Alaska

Regulatory Status— Cuvier's beaked whales (*Ziphius cavirostris*) are not listed as threatened or endangered under the ESA or depleted under the MMPA. The Alaska stock of Cuvier's beaked whales is not classified as strategic.

Habitat Preferences- World-wide, beaked whales normally inhabit continental slope (656-6,562 ft [200-2,000 m]) and deep oceanic waters (>6,562 ft [>2,000 m]), and only rarely stray over the continental shelf (Pitman 2002). Beaked whales are only occasionally reported in waters over the continental shelf. Cuvier's beaked whales generally are sighted in waters with a bottom depth greater than 656 ft (200 m) and are frequently recorded at depths of 3,280 ft (1,000 m) or more. Forney and Brownell (1996) made one sighting of Cuvier's beaked whales during surveys in the Aleutian Islands during 1994 in waters with a bottom depth of 13,123 to 16,404 ft (4,000 to 5,000 m). Rice and Wolman (1982) observed a group of six Cuvier's beaked whales in about 17,716 ft (5,400 m) of water southeast of Kodiak Island. Waite (2003) reported one sighting of a group of four Cuvier's beaked whales at the shelf break within the TMAA. There were no beaked whales detected acoustically or visually (although two groups of unidentified small whale were sighted) during the April 2009 survey of the TMAA (Rone et al. 2009).

Population Size and Trends— There is no population estimate for the Alaska stock of Cuvier's beaked whales (Angliss and Allen 2008). For purposes of acoustic impact modeling, a density of $0.0022/\text{km}^2$ was derived for Cuvier's beaked whales in the TMAA as described in detail in Appendix B.

Distribution— The general distribution of Cuvier's beaked whales is primarily derived from strandings, which indicated that they are the most widely distributed of the beaked whales. They occur in all three major oceans and most seas. In the north Pacific, they range north to the northern GOA, the Aleutian Islands, and the Commander Islands and as far south as Hawaii. Cuvier's beaked whales generally are sighted in waters with a bottom depth greater than 656 ft (200 m) and are frequently recorded in areas with depths of 3,281 ft (1,000 m) or more. Occurrence has been linked to physical features such as the continental slope, canyons, escarpments, and oceanic islands. (Angliss and Outlaw 2005)

Life History— Little is known of the feeding preferences of Cuvier's beaked whale. They may be mid-water and bottom feeders (Baird et al. 2005b) on cephalopods and, rarely, fish (MacLeod et al. 2003).

Reproduction/Breeding— Little is known of Cuvier's beaked whale reproductive behavior. There are no known areas used by Cuvier's beaked whales for reproduction or calving in the TMAA.

Diving Behavior— Recent research has provided considerable information regarding the complex patterns associated with the diving behavior of this species. Details regarding dive behavior information and how it was used in deriving parameters for input to the acoustic modeling are provided in Appendix B. In general, Cuvier's beaked whales feed on deep sea fish and squid and tend to dive for an hour or more to considerable depths to forage. Tagged Cuvier's beaked whale dive durations have been recorded for as long as 87 min and dive depths of up to 6,529 ft (1,990 m). (Baird et al. 2006)

Acoustics— MacLeod (1999) suggested that beaked whales use frequencies of between 300 Hz and 129 kHz for echolocation, and between 2 and 10 kHz, and possibly up to 16 kHz, for social communication. Blainville's beaked whales echolocation clicks were recorded at frequencies from 20 to 40 kHz (Johnson et al. 2004) and Cuvier's beaked whales at frequencies from 20 to 70 kHz (Zimmer et al. 2005). Soto et al. (2006) reported changes in vocalizations during diving on close approaches of large cargo ships which may have masked their vocalizations. Cuvier's beaked whales only echolocated below 200 m (656 ft) (Tyack et al. 2006a). Echolocation clicks are produced in trains (interclick intervals near 0.4 second) and individual clicks are frequency modulated pulses with durations of 200-300 microsecond; the center frequency was around 40 kHz with no energy below 20 kHz (Tyack et al. 2006a).

Impacts of Human Activity

Fisheries Interactions— From 1990 to 2002, six different commercial fisheries operating within the range of the Alaska stock of Cuvier's beaked whales were monitored for incidental take. These fisheries included Bering Sea (and Aleutian Islands) ground fish trawl, longline, and pot fisheries and GOA ground fish trawl, longline, and pot fisheries. No Cuvier's beaked whale mortalities were observed. (Angliss and Outlaw 2007)

Fisheries Interactions— As noted previously for Baird's beaked whales, mass strandings associated with naval training that may have included mid-frequency sonar is a concern for all beaked whales. Between 27 June and 19 July 2004, five beaked whales were discovered stranded at various locations along 1,600 mi (2,575 km) of the Alaskan coastline and one was found floating (dead) at sea. These whales included two Cuvier's beaked whales. As described in Appendix A in greater detail, these strandings were not associated with sonar use by the Navy. Additionally, prior to the Navy conducting the exercise (before 27 June), two Cuvier's beaked whales were discovered stranded at two separate locations along the Alaskan coastline (February 26 at Yakutat and June 1 at Nuka Bay).

Zimmerman (1991) reported that between 1975 and 1987, 19 Cuvier's beaked whales were found stranded from the eastern GOA to the western Aleutians. As noted previously, on average in Alaska there has been on average between zero and three beaked whale strandings documented per year (Jensen 2008).

4.3.3 Dall's Porpoise (*Phocoenoides dalli*)

Stock—Alaska

Regulatory Status— Dall's porpoises (*Phocoenoides dalli*) are not listed as threatened or endangered under the ESA or depleted under the MMPA. The Alaska stock of Dall's porpoise is not classified as strategic.

Habitat Preferences- Dall's porpoises are a cool- temperate to subarctic deepwater species found only in the North Pacific and adjacent seas. Cool water temperature (<63 degrees Fahrenheit [°F], 17 degrees Celsius [°C]) is characteristic of their primary habitat. Dall's porpoises are common along the shelf break, slope, and in offshore waters (Consiglieri et al. 1982, Calkins 1986). The waters of the TMAA are an area of primary occurrence.

Population Size and Trends— Numerous studies have documented the occurrence of Dall's porpoises in the Aleutian Islands and western GOA as well as in the Bering Sea. Using a population estimate based on vessel surveys during 1987–1991, and correcting for the tendency of this species to approach vessels, which has been suggested to result in inflated abundance estimates, perhaps by as much as five times, reported a minimum population estimate of 83,400 (CV=0.097) for the Alaska stock of Dall's porpoise. (Angliss and Outlaw 2008) Based on the derived density of 0.1892/km^2 for acoustic impact modeling (Appendix B), Dall's porpoises are the most common cetacean in the TMAA.

Distribution— Dall's porpoises are found from northern Baja California, Mexico, north to the northern Bering Sea and south to southern Japan (Jefferson et al. 1993). The species is only common between 32°N and 62°N in the eastern north Pacific (Morejohn 1979; Houck and Jefferson 1999). Dall's porpoises shift their distribution southward during cooler-water periods (Forney and Barlow 1998). Norris and Prescott (1961) reported finding Dall's porpoises in southern California waters only in the winter, generally when the water temperature was less than 59°F (15°C). Inshore/offshore movements off southern California have also been reported, with individuals remaining inshore in fall and moving offshore in the late spring (Norris and Prescott 1961, Houck and Jefferson 1999, Lagomarsino and Price 2001). Seasonal movements have also been noted off Oregon and Washington, where higher densities of Dall's porpoises were sighted offshore in winter and spring and inshore in summer and fall (Green et al. 1992).

Fiscus et al. (1976) suggested that Dall's porpoise is probably the most common cetacean from the northeast GOA to Kodiak Island. Dall's porpoises are regularly found throughout the GOA year-round. Sightings indicate a general seasonal shift in distribution in the GOA from east in April to west in May and south in June. Dall's porpoises are common along the shelf break, slope, and in offshore waters. Dall's porpoises are primarily found seaward of the 328 ft (100 m) isobaths in the GOA throughout the year. (Angliss and Outlaw 2008, DoN 2006). The April 2009 survey in the TMAA encountered 10 groups of Dall's porpoise totaling 59 individuals in both inshore and offshore strata (Rone et al. 2009).

Life History— Dall's porpoises feed primarily on small fish and squid (Houck and Jefferson 1999). Groups of Dall's porpoises generally include fewer than 10 individuals and are fluid, probably aggregating for feeding (Jefferson 1990, 1991; Houck and Jefferson 1999). There is a strong summer calving peak from June through August, and a smaller peak in March (Jefferson 1989). Animals reach sexual maturity at 3.5 to 8 years (Houck and Jefferson 1999).

Reproduction/Breeding— Calving for Dall's porpoise occurs in the north Pacific from early June through late July (Ferrero and Walker 1999). There are no known areas used by Dall's propoise for reproduction or calving in the TMAA.

Diving Behavior— Details regarding the characterization of diving behavior for input into acoustic impact modeling for Dall's porpoises are provided in Appendix B. Dall's porpoises feed on small fish and squid. In the GOA, Dall's porpoises primarily feed on lanternfish (myctophids). Hanson and Baird (1998) provided the first data on diving behavior for this species: an individual tagged for 41 min dove to a mean depth of 109.6 ft (33.4 m; Standard Deviation [S.D.] = ±23.9 m) for a mean duration of 1.29 min (S.D. = ±0.84 min). (DoN 2006)

Acoustics— Only short-duration pulsed sounds have been recorded from Dall's porpoises; this species apparently does not whistle often. Dall's porpoises produce short-duration (50 to 1,500 microsesond [μs]), high-frequency, narrow-band clicks, with peak energies between 120 and 160 kHz. There are no published data on hearing abilities of this species. However, based on the morphology of the cochlea, it is estimated that the upper hearing threshold is about 170 to 200 kHz (see Table 3-3). (DoN 2006)

Impacts of Human Activity

Fisheries Interactions— The Alaska Peninsula and Aleutian Island salmon driftnet fishery was monitored in 1990. One Dall's porpoise mortality was observed which extrapolated to an annual (total) incidental mortality rate of 28 Dall's porpoise. In addition, over a 5-year period (2000-2004), observations of the Bering Sea/Aleutian Islands pollock trawl fishery resulted in a mean annual mortality of 5.9 Dall's porpoises. This results in an estimated annual incidental kill rate in observed fisheries of 33.9 Dall's porpoises per year for the Alaska stock. (Angliss and Outlaw 2008)

4.3.4 Gray Whale (Eschrichtius robustus)

Stock—Eastern North Pacific

Regulatory Status— The ENP stock of gray whales was delisted given an increase in population so it was no longer considered "endangered" or "threatened" under the ESA. Subsequent review determined that the stock was neither in danger of extinction, nor likely to become endangered within the foreseeable future. The ENP stock is not classified as a "strategic" stock by NMFS. (Angliss and Allen 2008)

Habitat Preferences- Gray whales primarily occur in shallow waters over the continental shelf. Their feeding grounds are generally less than 223 ft (68 m) deep and most of the ENP stock can be found in summer feeding grounds north of the Aleutian Islands. During migration through the GOA en route from subtropical breeding grounds, gray whales' primary occurrence extends seaward 15 nm (28 km) from the shoreline within a narrow margin of the TMAA's northern boundary. A rare occurrence is expected seaward of the shelf break. (DoN 2006)

Population Size and Trends— Systematic counts of gray whales migrating south along the central California coast have been conducted most years since 1967, documenting the population increasing over the past several decades. The minimum population estimates for the ENP stock of gray whales using the mean of the 2000/01 and 2001/02 abundance estimates is 17,752 and the best estimate of 18,813 whales (CV = 0.07; Angliss and Allen 2008). For purposes of acoustic impact modeling, a density was estimated at 0.0125/km^2, and is applicable only for the farthest north area of the TMAA (2.75 percent of the area) as described in detail in Appendix B and illustrated in Figure 1.

Distribution— Gray whales are found only in the North Pacific. The ENP population is found from the upper Gulf of California, south to the tip of Baja California, and up the Pacific coast of North America to the Chukchi and Beaufort seas. This stock is known to summer in the shallow waters of the northern Bering Sea, Chukchi Sea, and western Beaufort Sea, but some individuals spend the summer feeding along the Pacific coast from southeastern Alaska to central California. Beginning in October, the whales migrate south to calving and breeding grounds on the west coast of Baja California and the southeastern Gulf of California. Some gray whales are known to deviate from the typical migration path/seasons; for example, gray whale calls have been documented off Barrow, Alaska, in the winter. (DoN 2006, Angliss and Allen 2008)

Gray whales are found along the shore in the northern GOA during migrations between breeding and feeding grounds. Individuals are expected to occur along the northern coast of the GOA between March and November; peak abundance is expected from April through May and in November and December.

The southbound migration begins in early October, when gray whales move from the Bering Sea through the Unimak Pass and along the coast of the GOA. The southbound migration continues into the winter season between October and January. Migration of gray whales past Kodiak Island peaks in mid-December. During the northbound migration, the peak of migration in the GOA is in mid-April. Although most gray whales migrate to the Bering Sea to feed, some whales do not complete the migration north but feed in coastal waters in the GOA and the Pacific Northwest. (DoN 2006)

Most gray whales follow the coast during migration and stay within 1.2 mi (2 km) of the shoreline, except when crossing major bays, straits, and inlets from southeastern Alaska to the eastern Bering Sea. However, gray whales are known to move further offshore between the entrance to Prince William Sound and Kodiak Island and between Kodiak Island and the southern part of the Alaska Peninsula. Gray whales use the nearshore areas of the Alaska Peninsula during the spring and fall migrations and are often found within the bays and lagoons, primarily north of the peninsula, during the summer. (DoN 2006) The April 2009 survey encountered one group of two gray whales within the western edge of the TMAA and two groups well outside the TMAA nearshore at Kodiak Island (Rone et al. 2009).

Life History— Most of the gray whales in the Eastern North Pacific stock spend the summer feeding in the northern Bering and Chukchi Seas. However, gray whales have been seen feeding in the summer off of Southeast Alaska, British Columbia, Washington, Oregon, and California. Each fall, the whales migrate south from Alaska to Baja California, in Mexico. The stock winters primarily in certain shallow, nearly landlocked lagoons and bays along the west coast of Baja California. Calves are born from early January to mid-February. The northbound migration begins in mid-February and continues through May, with cows and newborn calves migrating northward primarily between March and June along the U.S. west coast. (Angliss and Outlaw 2007)

Reproduction/Breeding— The winter breeding grounds consist of subtropical lagoons that are protected from the open ocean (Jones and Swartz 2002). There are no known areas used by gray whales for reproduction or calving in the TMAA.

Diving Behavior— Details regarding the characterization of diving behavior for input into acoustic impact modeling for gray whales are provided in Appendix B. When foraging, gray whales typically dive to 164 to 196 ft (50 to 60 m) for 5 min to about 8 min. When migrating, gray whales may remain submerged near the surface for 7 to 10 min and travel 1,640 ft (500 m) or more before resurfacing to breathe. Migrating gray whales sometimes exhibit a unique "snorkeling" behavior in which they surface cautiously, exposing only the area around the blow hole, exhale quietly without a visible blow, and sink silently beneath the surface. The maximum known dive depth is 557 ft (170 m) (DoN 2006, Jones and Swartz 2002).

Acoustics— Gray whales produce broadband signals ranging from 0.1 to 4 kHz (and up to 12 kHz). The most common sounds on the breeding and feeding grounds are knocks, which are broadband pulses from about 0.1 to 2 kHz (dominant frequency range: 0.327 to 0.825 kHz; see Table 3.8-3). The source level for knocks is approximately 142 dB re 1 µPa @ 1 m. During migration, individuals most often produce low-frequency (predominantly below 1.5 kHz) bonging sounds and moans. (DoN 2006)

The structure of the gray whale ear is evolved for low-frequency hearing. The ability of gray whales to hear frequencies below 2 kHz (as low as 0.8 kHz) has been demonstrated in playback studies and in their responsiveness to underwater noise associated with oil and gas activities. Gray whale responses to noise in these studies include startle responses (i.e., water disturbances, tail-lobbing); changes in swimming speed and direction to move away from the sound source; abrupt behavioral changes from feeding to avoidance, with a resumption of feeding after exposure; changes in calling rates and call structure; and changes in surface behavior, usually from traveling to milling. It was determined the threshold for inducing feeding interruptions from air gun noise was a received level of 173 dB re 1 µPa @ 1 m, and for continuous industrial noise, the threshold for inducing avoidance was a received level of approximately 120 dB re 1 µPa @ 1 m. (DoN 2006)

Impacts of Human Activity

Subsistence Interactions— Subsistence hunters in Alaska and Russia have traditionally harvested whales from the ENP stock of gray whales. Based upon reported taking of whales by subsistence hunters from 1995 to 1997 along with an agreement reached between the United States and Russia that the average annual harvest of gray whales would be 124, the annual subsistence take of gray whales averaged 122 whales during a 5-year period from 1999 to 2003. (Angliss and Allen 2008)

Vessel Collisions— The nearshore migration route used by gray whales makes ships strike a potential source of mortality. Between 1999 and 2003, the California stranding network reported four serious injuries or mortalities of gray whales caused by ship strikes. One ship strike was reported in Alaska in 1997. Additional mortality from ship strikes probably goes unreported because the whales either do not strand or do not have obvious signs of trauma. (Angliss and Allen 2008)

4.3.5 Harbor Porpoise (*Phocoena phocoena*)

Stock—Gulf of Alaska

Regulatory Status— Harbor porpoise (*Phocoena phocoena*) are not listed as threatened or endangered under the ESA or depleted under the MMPA. The Gulf of Alaska stock of harbor porpoise is classified as strategic.

Habitat Preferences- Harbor porpoises are generally found in cool temperate to subarctic waters over the continental shelf. This species is seldom found in waters warmer than 62°F (17°C). In Alaskan waters, harbor porpoises inhabit nearshore areas and are common in bays, estuaries, and tidal channels. Harbor porpoises are often found in coastal waters and in the GOA and Southeast Alaska; they occur most frequently in waters less than 328 ft (100 m) in depth. (DoN 2006, Angliss and Allen 2008) Waite (2003) reports a single sighting (two individuals) 27 nm (50 km) offshore, but within the 328 ft (100 m) isobath. The majority of the TMAA is well offshore of the normal habitat range for harbor porpoise. The April 2009 survey encountered 30 groups of harbor porpoise totaling 89 individuals but only one of these groups was located within the TMAA (Rone et al. 2009).

Population Size and Trends— Two of the nine stocks of harbor porpoises recognized along the U.S. Pacific coast are found near the TMAA: the Gulf of Alaska, and Southeast Alaska stocks. The boundaries of the Gulf of Alaska stock are Cape Suckling to Unimak Pass in the Aleutian Islands. The boundaries of the Southeast Alaska stock are northern border of British Columbia to Cape Suckling, Alaska (Angliss and Outlaw 2008). Given the distance from shore and the depth of the waters, individuals from the Southeast Alaska stock should not be present in the TMAA. Individuals from the Gulf of Alaska stock may rarely occur in the northern portion of the TMAA. There is a minimum population estimate of 41,854 for the Gulf of Alaska stock. There are not sufficient numbers of harbor porpoise present in the TMAA to allow for acoustic impact modeling given they are rare.

To derive an estimate for the number of harbor porpoise that may be exposed to potential MMPA Level B harassment (behavioral disturbance), an analysis of the approximate distribution of harbor porpoise in the Gulf of Alaska stock (occurring from Unimak Pass to Cape Suckling as presented in the stock assessment; Angliss and Outlaw 2006) was undertaken as a first step. The stock assessment information indicates an area for the GOA stock of approximately 69,829 nm^2 (239,597 km^2) with an abundance of 41,854 animals, resulting in the second highest density for a marine mammal species in the GOA (0.5993/nm^2 or 0.1747/km^2). The nearshore portion of the TMAA overlaps this approximate distribution by an area of 4,538 nm^2 (15,565 km^2). If an even distribution of harbor porpoise in the Gulf of Alaska stock is assumed, there would be 2,719 harbor porpoise in the portion of the TMAA that overlaps the distribution as presented in the stock assessment. While this is likely an overestimate for the number of animals present in the area given the TMAA is outside harbor porpoise habitat preferences, it will be assumed for purposes of this analysis that 2,719 harbor porpoise would be exposed to a sound level at or above 120 dB Sound Pressure Level (SPL) resulting in MMPA Level B behavioral harassment during one summer training event.

Distribution— Harbor porpoises are generally found in cool temperate to subarctic waters over the continental shelf in both the North Atlantic and North Pacific. Harbor porpoises regularly occur in the GOA year-round. They are common in nearshore waters of the northeast GOA and south of Kodiak Island on Albatross and Portlock banks. They also regularly occur in Kachemak Bay, Prince William Sound, Yakutat Bay, and southeast Alaska, particularly between April and September. Based on aerial surveys in coastal and offshore waters from Bristol Bay (eastern Bering Sea) to Dixon Entrance (southeast Alaska), harbor porpoises are abundant in Bristol Bay and between Prince William Sound and Dixon Entrance. Lower abundance estimates were calculated for Cook Inlet, Kodiak Island, and the south side of the Alaska Peninsula. (DoN 2006, Angliss and Allen 2008)

Life History— Harbor porpoises are not known to form stable social groupings, which is the typical situation for species in the porpoise family. In most areas, harbor porpoises are found in small groups consisting of just a few individuals. (DoN 2006)

Reproduction/Breeding— They mature at an earlier age, reproduce more frequently, and live for shorter periods than other toothed whales (Read and Hohn 1995). Calves are born in late spring (Read 1990, Read and Hohn 1995). Dall's and harbor porpoises appear to hybridize relatively frequently in the Puget Sound area (Willis et al. 2004). There are no known areas used by Harbor porpoises for reproduction or calving in the TMAA.

Diving Behavior— Harbor porpoises make brief dives, generally lasting less than 5 min. Tagged harbor porpoise individuals spend 3 to 7 percent of their time at the surface and 33 to 60 percent in the upper 7 ft (2 m) of the water column. Average dive depths range from 46 to 135 ft (14 to 41 m), with a maximum known dive of 741 ft (226 m), and average dive durations ranging from 44 to 103 sec. (DoN 2006)

Acoustics— Harbor porpoise vocalizations include clicks and pulses, as well as whistle-like signals. The dominant frequency range is 110 to 150 kHz, with source levels of 135 to 177 dB re 1 µPa @ 1 m. Echolocation signals include one or two low-frequency components in the 1.4 to 2.5 kHz range. (DoN 2006).

A behavioral audiogram of a harbor porpoise indicated the range of best sensitivity is 8 to 32 kHz at levels between 45 and 50 dB re 1 µPa @ 1 m; however, auditory-evoked potential studies showed a much higher frequency of approximately 125 to 130 kHz with two frequency ranges of best sensitivity. More recent psycho-acoustic studies found the range of best hearing to be 16 to 140 kHz (see Table 3-3), with a reduced sensitivity around 64 kHz and maximum sensitivity between 100 and 140 kHz. (DoN 2006)

Impacts of Human Activity

Fisheries Interactions— The Pacific cod longline, Pacific halibut longline, rockfish longline, and sablefish longline fisheries were monitored for incidental mortality by fishery observers from 2000 to 2004. No mortalities were observed for the Southeast Alaska or Gulf of Alaska stock of the harbor porpoise. However, monitoring in Prince William Sound (1990-1991), Cook Inlet (1999 and 2000), and Kodiak Island (2002) of salmon drift and set gillnet fisheries resulted in the observation of incidental mortalities. These mortalities extrapolated to an estimated mortality level of 71 animals per year for the Gulf of Alaska stock of harbor porpoise.

4.3.6 Killer Whale, Resident and Offshore (*Orcinus orca*)

There are at least three killer whale (*Orcinus orca*) ecotypes in the eastern north Pacific: "residents," "transients," and "offshore" killer whales. Resident animals often differ from both transient and offshore individuals by having a dorsal fin that is more curved and rounded at the tip, especially among mature females. Residents also exhibit five patterns of saddle patch pigmentation, two of which are shared with transients. Transients have more pointed dorsal fins, and closed saddle patches that extend further forward. Offshores are thought to be slightly smaller in body size than residents and transients and have dorsal fins and saddle patches resembling those of residents. (DoN 2006)

Stock—Eastern North Pacific Alaska Resident, Eastern North Pacific Northern Resident, Eastern North Pacific Offshore, Gulf of Alaska, Aleutian Island, and Bering Sea Transient, AT1 Transient; and West Coast Transient.

Regulatory Status— The ENP Alaska Resident, ENP Northern Resident, ENP Offshore, GOA, Aleutian Islands, and Bering Sea transient, and West Coast Transient stocks of killer whales are not listed as threatened or endangered under the ESA or classified as depleted or strategic under the MMPA. In June 2004, NMFS designated the AT1 Transient stock of killer whales as a "depleted" stock under the MMPA and therefore classified as strategic. (Angliss and Allen 2008). In the past, the AT1 Transient stock was one of the most frequently encountered and was sighted year-round in Prince William Sound in the 1980s. However, since the 1989 Exxon Valdez oil spill, the size of the AT1 Transient stock has been reduced by half. The AT1 Transient stock is not currently listed as threatened or endangered.

Habitat Preferences- Killer whales have the most ubiquitous distribution of any species of marine mammal, observed in virtually every marine habitat from the tropics to the poles and from shallow, inshore waters (and even rivers) to deep, oceanic regions. Although reported in tropical and offshore waters, killer whales occur in higher densities in colder and more productive waters of both hemispheres, with the greatest densities found at high latitudes. In the eastern north Pacific, including Alaskan waters, killer whales are found in protected inshore waters, as well as offshore waters. (DoN 2006)

Population Size and Trends— Killer whales are segregated socially, genetically, and ecologically into three distinct eco-type groups: residents, transients, and offshore animals. Resident killer whales primarily feed on fish. "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) and do not have known schedules and locations as resident whales do. Offshore whales do not appear to mix with the other types of killer whales (Black et al. 1997, Dahlheim et al. 1997). Most cetacean taxonomists agree that multiple killer whale species or subspecies occur worldwide (DoN 2006).

ENP Alaskan Resident stock individuals are found from southeastern Alaska to the Aleutian Islands and Bering Sea; intermixing has been documented among these three areas (Angliss and Outlaw 2007). The ENP Northern Resident stock occurs from British Columbia through part of southeastern Alaska. There are about 656 and 216 photoidentified individuals in the ENP Alaska Resident and ENP Northern Resident stocks, respectively (Angliss and Allen 2008).

The minimum population estimate for the Gulf of Alaska, Aleutian Islands, and Bering Sea Transient stock is 314 individuals based on photoidentification work. There is a minimum population estimate of 320 individuals in the West Coast Transient stock including about 225 in Washington State and British Columbia, and southeastern Alaska, and 105 off California. The population estimate for the ENP Stock of transient killer whales is 346. The minimum population estimate for the AT1 Transient stock is seven individuals based on photographs from recent years. (Angliss and Allen 2008)

The minimum population estimate for the ENP Offshore stock of killer whales is 1,214 individuals (Carretta et al. 2007). The total number of known Offshore killer whales is 211 individuals, but the proportion of time this transboundary stock spends in U.S. waters is unknown (Carretta et al. 2006). For purposes of acoustic impact modeling, a density of 0.010/km^2 was derived as representative for all killer whales in the TMAA as described in detail in Appendix B.

Distribution— Movement data on ENP Alaska Resident stock individuals have been documented based on photographic matches. Southeast Alaskan killer whale pods have been seen in Prince William Sound and in the GOA. Prince William Sound pods have been seen near Kodiak Island, but have never been observed in southeastern Alaska. Recent studies have documented very limited movements between the Bering Sea and GOA. (Angliss and Allen 2008, DoN 2006)

Transient killer whales in the eastern north Pacific spend most of their time along the outer coast, but visit Hood Canal and Puget Sound in search of harbor seals, sea lions, and other prey. Transient occurrence in inland waters appears to peak during August and September, which is the peak time for harbor seal pupping, weaning, and post-weaning. Offshore killer whales usually occur 9 mi (15 km) or more offshore but also visit coastal waters and occasionally enter protected inshore waters. Along the Pacific coast of North America, killer whales are found along the entire Alaskan coast, and are seen frequently in southeast Alaska and the area between Prince William Sound and Kodiak Island. (Angliss and Allen 2008; DoN 2006)

GOA, Aleutian Islands, and Bering Sea transients are seen throughout the GOA, including occasional sightings in Prince William Sound. Wade et al. (2003) noted that transients were more frequently seen from Shumagin Islands to the eastern Aleutian Islands. The AT1 Transient stock is primarily seen in Prince William Sound and in the Kenai Fjords region. At present, there is no information available to determine if this group regularly uses the TMAA. West coast transients are found from California to northern southeast Alaska. Some individual killer whales have been documented to move between the waters of southeast Alaska and central California. (Angliss and Allen 2008, DoN 2006)

The known range of the ENP Northern Resident stock includes Canadian waters from approximately Mid-Vancouver Island and throughout most of southeastern Alaskan waters. They have also been frequently seen in Washington state waters. (Angliss and Allen 2008, DoN 2006)

In Alaska, sightings of killer whales are widely distributed, mostly occurring in waters over the continental shelf, but also quite frequently in offshore waters. The Resident population is suspected to pass through the TMAA regularly during the summer based on limited satellite tagging data. The sympatric Gulf of Alaska, Aleutian Island, and Bering Sea transient population is suspected to spend considerable time in offshore waters, due to the infrequency of nearshore sightings; however, it is not certain how much time these killer whales spend in the TMAA. Members of the Offshore population have been seen only irregularly adjacent to the TMAA, and although it is likely they pass through it there is not data to document this. (Angliss and Allen 2008, DoN 2006)

There is no known seasonal component to the killer whale's occurrence in the TMAA. Resident, AT1 transient, and Gulf of Alaska, Aleutian Island, and Bering Sea transient populations all remain in the general area during the winter, however, there is no data that specifically places these whales in the TMAA due to lack of substantial research effort offshore and in winter. (Angliss and Allen 2008, DoN 2006)

The April 2009 GOALS survey visually detected six groups of killer whales totaling 119 individuals within the TMAA although there were additional acoustic detections as well (Rone et al. 2009). Analysis of photos taken for identification has not yet been completed and, at present, the specific eco-types for some of these detected killer whales have not been determined.

Life History— Diet in the eastern North Pacific is specific to the type of killer whale. The offshore ecotype appears to eat mostly fish (Bigg 1982, Morton 1990, Heise et al. 2003, Herman et al. 2005). Few details are known about the biology of offshore killer whales, but they commonly occur in groups of 20 to 75 individuals (Wiles 2004).

Transient killer whales show greater variability in habitat use, with some groups spending most of their time foraging in shallow waters close to shore while others hunt almost entirely in open water (Heimlich-Boran 1988, Felleman et al. 1991, Baird and Dill 1995, Matkin and Saulitis 1997). Transient killer whales feed on marine mammals and some seabirds, but apparently no fish (Morton 1990, Baird and Dill 1996, Ford et al. 1998, Ford and Ellis 1999, Ford et al. 2005). Transient killer whales travel in small, matrilineal groups, but they typically contain fewer than 10 animals and their social organization generally is more flexible than in residents (Morton 1990, Ford and Ellis 1999). These differences in social organization probably relate to differences in foraging (Baird and Whitehead 2000).

Reproduction/Breeding— There is no information on the reproductive behavior of killer whales in this area. Among resident killer whales in the northeastern Pacific, births occur largely from October to March, although births can occur year-round (Olesiuk et al. 1990, Stacey and Baird 1997).

While there is a lack of data on the reproduction/breeding activities of transient killer whales, it is thought that calving occurs year-round, but tends to peak in fall through spring. (Angliss and Outlaw 2007) There are no known areas used by killer whales for reproduction or calving in the TMAA.

Diving Behavior— The maximum depth recorded for free-ranging killer whales diving off British Columbia is 866 ft (264 m) (Baird et al. 2005a). On average, however, for seven tagged individuals, less than one percent of all dives examined were to depths greater than 98 ft (30 m). A trained killer whale dove to a maximum of 853 ft (260 m) (Baird et al. 2003). The longest duration of a recorded dive from a radio-tagged killer whale was 17 min (DoN 2006). Details regarding the diving behavior as characterized for acoustic modeling input are provided in Appendix B.

Acoustics— Killer whales produce a wide-variety of clicks and whistles, but most of this species' social sounds are pulsed, with frequencies ranging from 0.5 to 25 kHz (dominant frequency range: 1 to 6 kHz). Echolocation clicks recorded for this species indicate source levels ranging from 195 to 224 dB re: 1 μPa @ 1 m peak-to-peak (see Table 3.8-3), dominant frequencies ranging from 20 to 60 kHz, and durations of 80 to 120 microseconds (μsec). Source levels associated with social sounds have been calculated to range from 131 to 168 dB re 1 μPa @ 1 m and have been demonstrated to vary with vocalization type (e.g., whistles: average source level of 140.2 dB re 1 μPa @ 1 m, variable calls: average source level of 146.6 dB re 1 μPa @ 1 m, and stereotyped calls: average source level 152.6 dB re 1 μPa @ 1 m). Additionally, killer whales modify their vocalizations depending on social context or ecological function (i.e., short-range vocalizations [<5.4 nm {10 km} range]) are typically associated with social and resting behaviors and long-range vocalizations [5.4 to 8.6 nm {10 to 16 km} range] associated with travel and foraging). (DoN 2006)

Resident killer whales are very vocal, making calls during all types of behavioral states. Acoustic studies of resident killer whales in the Pacific Northwest have found that there are dialects in their highly stereotyped, repetitive discrete calls, which are group-specific and shared by all group members. These dialects likely are used to maintain group identity and cohesion, and may serve as indicators of relatedness that help in the avoidance of inbreeding between closely related whales. Dialects have been documented in northern Norway and southern Alaskan killer whale populations and are likely to occur in other regions as well. Residents do not need to alter their sounds (i.e., frequency or amplitude) when hunting fishes, since most of their prey (i.e., salmonids) are not capable of hearing in this frequency range (i.e., >20 kHz).

Transient killer whales, conversely, appear to use passive listening as a primary means of locating prey, call less often, and frequently vocalize or use high-amplitude vocalizations only when socializing (i.e., not hunting), trying to communicate over long distances, or after a successful attack, as a result of their prey's ability (i.e., primarily other marine mammal species) to hear or "eavesdrop" on their sounds. Discrete pulsed calls were recently identified in the vocal repertoire of the AT1 transients and for transients off southern Alaska, indicating that transients may maintain reproductive and socially isolated subpopulations using distinct vocalizations as well. (DoN 2006)

Both behavioral and auditory brainstem response (ABR) techniques indicate killer whales can hear a frequency range of 1 to 100 kHz and are most sensitive at 20 kHz, which is one the lowest maximum-sensitivity frequency known among toothed whales (DoN 2006).

Impacts of Human Activity

Fisheries Interactions— Three commercial fisheries in Alaska have caused serious injuries or mortalities of killer whales (any stock) between 2000 and 2004: the Bering Sea and Aleutian Islands flatfish trawl, the Bering Sea and Aleutian Islands pollock trawl and the Bering Sea and Aleutian Islands pacific cod longline. Recently observers have collected tissue samples of many of the killer whales which were killed incidental to commercial fisheries. Genetics analysis have indicated that the mortalities incidental to the Bering Sea and Aleutian Islands flatfish trawl and the Bering Sea and Aleutian Islands Pacific cod fisheries are of the "resident" type, and mortalities incidental to the Bering Sea and Aleutian Islands pollock trawl fisheries are of the "transient" type. The estimated minimum mortality rate for resident killer whales incidental to U.S. commercial fisheries recently monitored is 1.5 animals per year, based completed on observer data. The estimated minimum mortality rate for transient killer whales incidental to U.S. commercial fisheries recently monitored is 0.4 animals per year, based completely on observer data. (Angliss and Allen 2008)

Other Mortality— During the 1992 killer whale surveys conducted in the Bering Sea and western GOA, 9 of 182 individual whales in 7 of the 12 pods encountered had evidence of bullet wounds. The relationship between wounding due to shooting and survival is unknown. There have been no obvious bullet wounds observed on killer whales during recent surveys in the Bering Sea and western GOA. However, researchers have reported that killer whale pods in certain areas exhibit vessel avoidance behavior, which may indicate that shootings occur in some places. (Angliss and Allen 2008)

4.3.7 Minke Whale (Balaenoptera acutorostrata)

Stock—Alaska

Regulatory Status— Minke whales (*Balaenoptera acutorostrata*) are not listed as threatened or endangered under the ESA or designated as depleted under the MMPA. Because minke whales are considered common in the waters off Alaska, the Alaska stock is not considered a strategic stock.

Habitat Preferences- Minke whales typically occupy waters over the continental shelf, including inshore bays and some estuaries. In the eastern north Pacific, minke whales are found feeding off California and Washington State in waters over the continental shelf. Based on whaling catches and surveys worldwide, there is also a deep-ocean component to the minke whale's distribution. In the western North Pacific, minke whales occur extensively in deep waters. Most sightings of minke whales in the central-eastern Bering Sea occur along the upper slope in waters with a bottom depth of 328 to 656 ft (100 to 200 m). Minke whales are relatively common in the Bering and Chukchi Seas and in the inshore areas of the GOA. (DoN 2006)

Population Size and Trends— The NMFS recognizes three stocks of minke whales within the Pacific U.S. EEZ: a California/Oregon/Washington stock, an Alaskan stock, and a Hawaiian stock (Carretta et al. 2006). There are no current estimates of abundance are available for minke whales in Alaskan waters (Angliss and Allen 2008). For purposes of acoustic impact modeling, a density of 0.0006/km^2 was derived for minke whales in the TMAA as described in detail in Appendix B.

Distribution— Minke whales are distributed in polar, temperate, and tropical waters (Jefferson et al. 1993); they are less common in the tropics than in cooler waters. Minke whales are present in the North Pacific from near the equator to the Arctic. The number of sightings of minke whales in the GOA is generally sparse. The summer range extends to the Chukchi Sea. In the winter, minke whales are found south to within 2° of the equator. The distribution of minke whale vocalizations (specifically, “boings”) suggests that the winter breeding grounds are the offshore tropical waters of the North Pacific Ocean. In the northern part of their range, minke whales are believed to be migratory, although there is no obvious migration from low-latitude, winter breeding grounds to high-latitude, summer feeding locations in the western North Pacific as there is in the North Atlantic. However, there are some monthly changes in densities in both high and low latitudes. Minke whales are seen in several locations year-round in the eastern north Pacific. (Angliss and Allen 2008)

It is believed that minke whales are more abundant in the nearshore waters of the Aleutian Islands than in the waters of the TMAA. Minke whales are known to be a migratory species; however, the patterns are not as well-known or defined as for some other species, such as gray and humpback whales. There are no winter sightings of this species in this area. (DoN 2006)

The number of sightings of minke whales in the GOA is generally sparse (DoN 2006). Large numbers of minke whales were reported at Portlock Bank (in the TMAA) and Albatross bank (west of the TMAA) during May 1976; however, subsequent NMFS surveys encountered none at those locations (Fiscus et al. 1976). Six sightings in shallow water (<656 ft [200 m]) and two in deep water (>3,281 ft [1,000 m]) were reported in 1987. Waite (2003) reported three sightings at or inshore of the shelf break in the northern margin of the TMAA. Two encounters totaling three individual minke whales occurred on the shelf during the April 2009 survey although only one of these encounters (at Portlock Bank) was within the TMAA (Rone et al. 2009.

Life History— Although minke whales are distributed in polar, temperate, and tropical waters (Jefferson et al. 1993), there is no obvious migration from low-latitude, winter breeding grounds to high-latitude, summer feeding locations in the western North Pacific (Horwood 1990).

Reproduction/Breeding— Stewart and Leatherwood (1985) suggested that mating occurs in winter or early spring although it had never been observed. There are no known areas used by minke whales for reproduction or calving in the TMAA.

Diving Behavior— Details of minke whale dive behavior as characterized for acoustic modeling are provided in Appendix B. A general surfacing pattern of minke whales consisting of about four surfacings interspersed by short-duration dives averaging 38 sec have been recorded. After the fourth surfacing, there was a longer duration dive ranging from approximately 2 to 6 min. Minke whales are lunge-feeding “gulpers,” like most other rorquals. (DoN 2006)

Acoustics— Recordings of minke whale sounds indicate the production of both high- and low-frequency sounds (range: 0.06 to 20 kHz, see Table 3.8-3). Minke whale sounds have a dominant frequency range of 0.06 kHz to greater than 12 kHz, depending on sound type. There are two basic forms of pulse trains: a “speed-up” pulse train (dominant frequency range: 0.2 to 0.4 kHz) with individual pulses lasting 40 to 60 milliseconds (ms), and a less common “slow-down” pulse train (dominant frequency range: 50 to 0.35 kHz) lasting for 70 to 140 ms. Source levels for this species have been estimated to range from 151 to 175 dB re 1 µPa @ 1 m. Source levels for some minke whale sounds have been calculated to range from 150 to 165 dB re 1 µPa @ 1 m. In the Southern Hemisphere a complex and stereotyped sound sequence ("star-wars vocalization") was recorded. This sound sequence spanned a frequency range of 50 Hz to 9.4 kHz. Broadband source levels between 150 and 165 dB re 1 µPa @ 1 m were calculated. "Boings" recorded in the North Pacific have many striking similarities to the star-wars vocalization in both structure and acoustic behavior. "Boings," recently confirmed to be produced by minke whales and suggested to be a breeding display, consist of a brief pulse at 1.3 kHz followed by an amplitude-modulated call with greatest energy at 1.4 kHz, with slight frequency modulation over a duration of 2.5 sec. (DoN 2006) While no empirical data on hearing ability for this species are available, Ketten (1997) hypothesized that mysticetes are most adapted to hear low to infrasonic frequencies.

Impacts of Human Activity

Fisheries Interactions— Six different commercial fisheries operating in Alaska waters within the range of the Alaska minke whale stock were monitored for incidental take by NMFS observers during 2000-2004: Bering Sea and Aleutian Islands groundfish trawl, longline and pot fisheries, and GOA groundfish trawl, longline, and pot fisheries. The Bering Sea/Aleutian Islands groundfish trawl fisheries caused one mortality of a minke whale in 2000. The total estimated mortality and serious injury incurred by this stock as a result of interactions with U.S. commercial fisheries is 0.32 minke whales annually.

4.3.8 Pacific White-Sided Dolphin (*Lagenorhynchus obliquidens*)

Stock—North Pacific

Regulatory Status—The Pacific white-sided dolphins (*Lagenorhynchus obliquidens*) are not listed as threatened or endangered under the ESA or depleted under the MMPA. The North Pacific stock is not classified as strategic.

Habitat Preferences- Pacific white-sided dolphins occur in temperate North Pacific waters over the outer continental shelf and slope, and in the open ocean. In the eastern north Pacific, the species occurs from the southern Gulf of California, north to the GOA, west to Amchitka in the Aleutian Islands, and is rarely encountered in the southern Bering Sea. The species is commonly found on both the high seas and along the continental margins, and animals are known to enter the inshore passes of Alaska, British Columbia, and Washington. (Angliss and Allen 2008, DoN 2006)

Population Size and Trends— The minimum population estimate for the North Pacific stock is 26,880 (CV=0.90) individuals (Angliss and Allen 2008). For purposes of acoustic impact modeling, a density of 0.0208/km^2 was derived for Pacific white-sided dolphins in the TMAA as described in detail in Appendix B.

Distribution— Pacific white-sided dolphins occur across the central North Pacific waters to latitudes as low as (or lower than) 38°N and northward to the Bering Sea and coastal areas of southern Alaska. Surveys suggest a seasonal north-south movement of Pacific white-sided dolphins in the eastern north Pacific, with animals found primarily off California during the colder water months and highest densities shifting northward into Oregon and Washington State as water temperatures increase during late spring and summer. (Angliss and Allen 2008; DoN 2006)

Pacific white-sided dolphins occur regularly year-round throughout the GOA. They are widely distributed along the shelf break, continental slope, and in offshore waters. Inshore movements of Pacific white-sided dolphins are not common, but instances have been documented in Washington State, British Columbia, and southeast Alaska. In Alaska, peak abundance is between July and August, when Pacific white-sided dolphins tend to congregate near the Fairweather Grounds in the southeastern GOA and Portlock Bank in the northeast part of the TMAA. (Angliss and Allen 2008; DoN 2006)

Previous survey data did not indicate the potential for a large number of Pacific white-sided dolphins in the vicinity of the TMAA (DoN 2006). Waite (2003), however, reported sighting two large groups (an average group size 56) just off Kenai Peninsula. This was previously characterized as an area of rare occurrence (relatively shallow waters) (DoN 2006). As a result of this new information, for purposes of acoustic impact modeling Pacific white-sided dolphins are analyzed as having the second highest density for cetaceans in the TMAA. The GOALS survey encountered Pacific white-sided dolphins only once (a group of 60 individuals) although this was outside the TMAA inside the shelfbreak to the southeast of Kodiak Island (Rone et al. 2009).

Life History— The diet in the eastern North Pacific includes cephalopods and fish (Schwartz et al. 1992, Black 1994, Heise 1997, Brownell et al. 1999, Morton 2000), and includes salmonids off Washington (Stroud et al. 1981). In this gregarious species, group sizes range from tens to thousands of dolphins (Leatherwood et al. 1984). They frequently aggregate with Risso's and northern right whale dolphins (Brownell et al. 1999).

Reproduction/Breeding— Calving occurs from June through August (Heise 1997). There are no known areas used by pacific white-sided dolphins for reproduction or calving in the TMAA.

Diving Behavior— Details regarding the characterization of diving behavior for input into acoustic impact modeling for Pacific white-sided dolphins are provided in Appendix B. Pacific white-sided dolphins in the eastern north Pacific feed primarily on epipelagic fishes and cephalopods. This does not appear to be a deep-diving species. Based on feeding habits, it has been inferred that Pacific white-sided dolphins dive to at least 120 m. The majority of foraging dives last less than 15 to 25 sec. (DoN 2006)

Acoustics— Vocalizations produced by Pacific white-sided dolphins include whistles and echolocation clicks. Whistles are in the frequency range of 2 to 20 Hz. Echolocation clicks range in frequency from 50 to 80 kHz (see Table 3-3); the peak amplitude is 170 dB re 1 µPa @ 1 m. (DoN 2006)

Tremel et al. (1998) measured the underwater hearing sensitivity of Pacific white-sided dolphins from 0.075 kHz through 150 kHz. The greatest sensitivities were from 2 to 128 kHz, while the lowest measurable sensitivities were 145 dB at 100 Hz and 131 dB at 140 kHz. Below 8 Hz and above 100 kHz, this dolphin's hearing was similar to that of other toothed whales. (DoN 2006)

Impacts of Human Activity

Fisheries Interactions— As a result in changes in fishery practices, there were no serious injuries or mortalities incidental to observed commercial fisheries between 2000 and 2004 for this species. (Angliss and Allen 2008)

4.3.9 Stejneger's Beaked Whale (*Mesoplodon stejnegeri*)

Stock—Alaska

Regulatory Status— Stejneger's beaked whales (*Mesoplodon stejnegeri*) are not listed as threatened or endangered under the ESA or depleted under the MMPA. The Alaska stock is not classified as strategic.

Habitat Preferences- Stejneger's beaked whales (also called Bering Sea beaked whales) appear to prefer cold-temperate and subpolar waters, although strandings have been reported as far south as Monterey, California (Reeves et al. 2002). World-wide, beaked whales normally inhabit continental slope and deep oceanic waters (>656 ft [200 m]). In many locales, occurrence patterns have been linked to physical features, in particular, the continental slope, canyons, and escarpments, and oceanic islands. Off Alaska, this species has been observed in waters ranging in bottom depth from 2,395 to 5,118 ft (730 to 1,560 m) on the steep slope of the continental shelf as it drops off into the Aleutian Basin which exceeds 11,483 ft (3,500 m) in bottom depth. (DoN 2006)

Population Size and Trends— No current estimates of abundance are available for Stejneger's beaked whales in Alaskan waters (Angliss and Allen 2008). Groups of 3 to 15 Stejneger's beaked whales were sighted on a number of occasions in the 1980s near the central Aleutian Islands (Rice 1986). There were no beaked whales detected acoustically or visually (although two groups of unidentified small whale were sighted) during the April 2009 survey of the TMAA (Rone et al. 2009). It has been suggested, however, that Stejneger's beaked whales are probably the most common beaked whales in these Alaskan waters (DoN 2006). For that reason, analysis of impacts for Stejneger's beaked whales will be considered using the results of acoustic impact modeling from Cuvier's beaked whales as a surrogate, given that sufficient information exists for Cuvier's beaked whales, they are in the same taxonomic family, and the predicted density of Cuvier's beaked whale in GOA is higher than that of Baird's beaked whales and therefore presumably errs on the side of overestimation.

Distribution— Stejneger's beaked whales (also called Bering Sea beaked whales) appear to prefer cold-temperate and subpolar waters and are found only in the North Pacific. The Alaska stock is recognized as separate from the species off California (Angliss and Outlaw 2007). Off Alaska, this species has been observed in waters ranging in bottom depth from 730 to 1,560 m (2,395 to 5,118 ft) on the steep slope of the continental shelf as it drops off into the Aleutian Basin (which exceeds 3,500 m [11,482 ft] in bottom depth) (DoN, 2006). Stejneger's beaked whales are found only in the North Pacific. The species range from the waters off southern California, north to the Bering Sea, and south to the Sea of Japan (Reeves et al. 2003).

Life History— Observed group sizes for beaked whales are typically small. Stejneger's beaked whales have been observed in groups of 5 to 15 individuals, often containing individuals of mixed sizes (Jefferson et al. 1993). Most sightings of beaked whales are brief since these whales are often difficult to approach and they actively avoid aircraft and vessels (e.g., Würsig et al. 1998).

Reproduction/Breeding— There is no available information on the reproduction or breeding of this species. There are no known areas used by Stejneger's beaked whales for reproduction or calving in the TMAA.

Diving Behavior— Most sightings of beaked whales are brief since these whales are often difficult to approach, and they actively avoid aircraft and vessels. Stejneger's beaked whale stomach contents include squids and pelagic fish. Until recently, it was thought that all beaked whales probably feed at or close to the bottom in deep oceanic waters, taking whatever suitable prey was encountered or was locally abundant, by suction-feeding. However, based on recent tagging data from Cuvier's and Blainville's beaked whales, it is suggested that feeding might actually occur at midwater rather than only at or near the bottom. Durations of long dives for *Mesoplodon* species are over 20 min. (DoN 2006)

Acoustics— There is no information available for Stejneger's beaked whale vocalizations. Sounds recorded from beaked whales are, in general, divided into two categories: whistles and pulsed sounds (clicks), with whistles likely serving a communicative function, and pulsed sounds being important in foraging and/or navigation. Whistle frequencies are about 2 to 12 kHz, while pulsed sounds range in frequency from 300 Hz to 135 kHz, however, higher frequencies may not be recorded due to equipment limitations. (DoN 2006)

There is no empirical information available on the hearing abilities of Stejneger's beaked whales. (DoN 2006)

Impacts of Human Activity

Fisheries Interactions— From 1990 to 2002, six different commercial fisheries operating within the range of the Alaska stock of Stejneger's beaked whale were monitored for incidental take. These fisheries included Bering Sea (and Aleutian Islands) ground fish trawl, longline, and pot fisheries and GOA groundfish trawl, longline, and pot fisheries. No Stejneger's beaked whale mortalities were observed. (Angliss and Outlaw 2007)

4.4 NON-ESA PINNIPED SPECIES

4.4.1 California Sea Lion (*Zalophus californianus*)

Stock—United States

Regulatory Status— California sea lions (*Zalophus californianus*) are not listed as threatened or endangered under the ESA or depleted under the MMPA. The U.S. stock is not classified as strategic.

Habitat Preferences- Alaska waters are north of the main breeding and feeding range located in California. California sea lions congregate near rookery islands in California waters and typically feed over the continental shelf staying within approximately 27 nm (50 km) of rookery islands although are occasionally sighted up to several hundred kilometers offshore (DoN 2006). California sea lions recorded in Alaska usually are observed at Steller sea lion rookeries and haulout sites and are present throughout the year (DoN 2006).

Population Size and Trends— The U.S. stock of California sea lions can be found in the GOA. The estimated stock is 238,000 individuals (Carretta et al. 2007b). This number is from counts during the 2001 breeding season of animals that were ashore at the four major rookeries in Southern California and at haulout sites north to the Oregon/California border. Sea lions that were at sea or were hauled out at other locations were not counted (Carretta et al. 2007b). The general trend for this stock is that the population is growing (NMFS 2007). There are not sufficient numbers of individuals of this species present in the TMAA to allow for acoustic impact modeling given they are rare.

Distribution— The primary rookeries for California sea lions are located on the California Channel Islands. California sea lions appear to be extending their feeding range farther north and increasing numbers of sightings are recorded in Alaskan waters (Maniscalco et al. 2004). The first recorded account of a California sea lion in Alaska was in 1973 at Point Elrington in the northern GOA (Maniscalco et al. 2004). Since then, California sea lions have been sighted throughout Alaska from Forrester Island in southeast Alaska to St. Matthews Bay, Prince William Sound, and St. Paul Island in the Bering Sea. Both male and female California sea lions have been observed as far north as the Pribilof Islands in the Bering Sea in recent years (Maniscalco 2002, DoN 2006). The few California sea lions recorded in Alaska usually are observed at Steller sea lion rookeries and haulout sites with most sightings recorded between March and May although they may be found in the GOA throughout the year. (Maniscalco et al. 2004, DoN 2006).

Life History— Survey data from 1975 to 1978 were analyzed to describe the seasonal shifts in the offshore distribution of California sea lions (Bonnell and Ford 1987). During summer, the highest densities were found immediately west of San Miguel Island. During autumn, peak densities of sea lions were centered on Santa Cruz Island. During winter and spring, peak densities occurred just north of San Clemente Island. The seasonal changes in the center of distribution were attributed to changes in the distribution of the prey species. If California sea lion distribution is determined primarily by prey abundance, these same areas might not be the center of sea lion distribution every year.

The distribution and habitat use of California sea lions vary with the sex of the animals and their reproductive phase. Adult males haul out on land to defend territories and breed from mid-to-late May until late July. Individual males remain on territories for 27–45 days without going to sea to feed. During August and September, after the mating season, the adult males migrate northward to feeding areas as far away as the GOA (Lowry et al. 1991). They remain there until spring (March–May), when they migrate back to the breeding colonies. Distribution of immature California sea lions is less well known, but some make northward migrations that are shorter in length than the migrations of adult males (Huber 1991). However, most immature seals are presumed to remain near the rookeries (Lowry et al. 1991). Adult females remain near the rookeries throughout the year.

Reproduction/Breeding— Most sea lion births occur from mid-June to mid-July (peak in late June) on the island rookeries in California and Mexico. GOA is outside the known breeding range for California sea lion. There are no known areas used by California sea lions for reproduction or calving in the TMAA.

Diving Behavior— California sea lions usually do not need to dive very deeply, since most of their food is found in shallow waters, about 85 to 243 ft (26 to 74 m) deep. They can, however, dive to depths of about 900 ft (274 m). California sea lions typically stay submerged 3 min or less; however, they can remain submerged for as long as 10 min. (Carretta et al. 2007b)

Acoustics— In air, California sea lions make incessant, raucous barking sounds; these have most of their energy at less than 2 kHz. The male barks have most of their energy at less than 1 kHz. Males vary both the number and rhythm of their barks depending on the social context; the barks appear to control the movements and other behavior patterns of nearby conspecifics. Females produce barks, squeals, belches, and growls in the frequency range of 0.25 to 5 kHz, while pups make bleating sounds at 0.25 to 6 kHz (see Table 3.8-3). California sea lions produce two types of underwater sounds: clicks (or short-duration sound pulses) and barks. All underwater sounds have most of their energy below 4 kHz. (DoN 2006)

The range of maximal sensitivity underwater is between 1 and 28 kHz. Functional underwater high frequency hearing limits are between 35 and 40 kHz, with peak sensitivities from 15 to 30 kHz. California sea lions show relatively poor hearing at frequencies below 1,000 Hz. Peak sensitivities in air are shifted to lower frequencies; the effective upper hearing limit is approximately 36 kHz. The best range of sound detection is from 2 to 16 kHz. Older sea lions (22 to 25 years of age) show in-air and underwater hearing losses that range from 10 dB at lower frequencies to 50 dB near the upper frequency limit. It has been determined that hearing sensitivity generally worsens with depth—hearing thresholds were lower in shallow water, except at the highest frequency tested (35 kHz), where this trend was reversed. (DoN 2006)

Impacts of Human Activity

Fisheries Interactions— Between 2000 and 2004, the mean annual serious injury and mortality to California sea lions from fisheries in California was 159 individuals. Other mortalities (boat collisions, power plant intake entrapment, shootings, marine debris, and unknown) added an additional 74 sea lions annually (NMFS 2007).

4.4.2 Harbor Seal (*Phoca vitulina richardsi*)

Stock— Three separate stocks of harbor seals are currently recognized in Alaska waters although there is substantial evidence that the population is more finely divided and may consist of a minimum of 12 stocks (DoN 2006, Angliss and Allen 2008). The three currently recognized stocks under MMPA are: Southeast Alaska stock (the Alaska/British Columbia border to Cape Suckling, Alaska), the Bering Sea stock (including all waters north of Unimak Pass), and the Gulf of Alaska stock (Cape Suckling, Alaska to Unimak Pass and throughout the Aleutian Islands). Animals from the Gulf of Alaska stock may be found in the TMAA.

Regulatory Status— Harbor Seal (*Phoca vitulina richardsi*) are not listed as threatened or endangered under the ESA or depleted under the MMPA. The U.S. stock is not classified as strategic.

Habitat Preferences- Harbor seals are coastal animals that primarily occur within 11 nm (20 km) from shore (Baird 2001, Lowery et al. 2001, Small et al. 2005). Harbor seals are considered abundant throughout most of their range which extends from Baja California to the eastern Aleutian Islands. In Alaska, they range from the Dixon Entrance to Kuskokwim Bay, are widely distributed along the coastal GOA (Angliss and Outlaw 2007), and are also found on offshore islands (Hoover 1988). There are over 300 coastal haulout sites for harbor seals in the GOA (Boveng et al. 2003). Harbor seals are abundant in fjords with tidewater glaciers, Prince William Sound, in several areas in the Kodiak Archipelago, and in major estuaries, particularly along the north side of the Alaska Peninsula (Hoover 1988, Lowrey et al. 2001, Boveng et al. 2003). There are haul outs along the shoreline of southeast Alaska, the south side of the Alaska Peninsula, the Aleutian Islands, and Middleton and Montague Islands (Hoover 1988, Lowrey et al. 2001). There is none of the harbor seal's preferred coastal habitat within the waters of the TMAA.

Population Size and Trends— Minimum population estimates for the Gulf of Alaska stock is 45,975 (CV=0.04) (Angliss and Allen 2008).

Distribution— The harbor seal is one of the most widespread of the pinniped species distributed from the eastern Baltic Sea, west across the Atlantic and Pacific Oceans to southern Japan, along the coast and offshore islands of Gulf of Alaska (DoN 2006). The harbor seal's preferred coastal habitat does not extend into the waters of the TMAA. Studies using satellite tags have documented the movements and home range of harbor seals in the vicinity of the TMAA (Lowry et al. 2001, Small et al. 2005). Although these tagging studies have documented harbor seal movement into deep water (beyond the shelf break) in the GOA, these movements are the exception. With few exceptions, harbor seals will be located in shallow nearshore areas and not at sea in the TMAA. Harbor seals, therefore, should be very rare in the small section of the TMAA nearest Kenai Peninsula, Montague Island, and Middleton Island. No harbor seals were encountered within the TMAA during the April 2009 GOALS survey (Rone et al. 2009).

Life History— On land, harbor seals tend to congregate in small groups of about 30 to 80 individuals, although larger groups are found in areas where food is plentiful. In Alaska, group size at haulouts ranges from 25 animals to more than 1,000 in some areas. (DoN 2006)

Information from tagged seals has indicated movement from haulouts to sea was age dependent with 3-5 nm (5-10 km) for adults and 5-14 nm (10-25 km) for juveniles (Lowry et al. 2001). Although some harbor seal pups made extensive movements, approximately 97% of pups were located less than 25 km from their haulouts (Small et al. 2005).

Reproduction/Breeding— In the Gulf of Alaska, male harbor seals attain sexual maturity around 5 to 6 years of age, while females are usually sexually mature at 5 years. Pups are typically born from late May through June. In general, the pupping season lasts up to 10 weeks with a two-week peak. Suckling harbor seal pups spend as much as 40% of their time in the water. The nursing period is approximately four to six weeks and after the pups are weaned, mating, which takes place in the water, may take place shortly thereafter. In the Gulf of Alaska, mating takes place from late June through July. Delayed implantation occurs for about 11 weeks after mating. (Don 2006)

Diving Behavior— Harbor seals are generally shallow divers. About 50% of their diving is shallower than 40 m, and 95% is shallower than 250 m. Dive durations are typically shorter than 10 min, with about 90% lasting less than 7 min. A tagged harbor seal in Monterey Bay dove as deep as 481 m. Harbor seal pups swim and dive with their mothers, although they dive for short periods compared with their mothers. Recorded dive durations for older individuals may be as long as 32 min. (DoN 2006)

Acoustics— Harbor seal males produce a variety of low-frequency (<4 kHz) in-air vocalizations including snorts, grunts, and growls, while pups make individually unique calls for mother recognition (contain multiple harmonics with main energy below 0.35 kHz). Adult males also produce several underwater sounds during the breeding season that typically range from 0.025 to 4 kHz (duration range: 0.1 s to multiple seconds) with individual variation in the dominant frequency range of sounds between different males. (DoN 2006)

Harbor seals hear nearly as well in air as underwater (Kastak and Schusterman 1998). Harbor seals hear frequencies from 1 to 180 kHz (most sensitive at frequencies below 50 kHz; above 60 kHz sensitivity rapidly decreases) in water and from 0.25 kHz to 30 kHz in air (most sensitive from 6 to 16 kHz using behavior and auditory brainstem response testing). (DoN 2006)

Impacts of Human Activity

Fisheries Interactions— Harbor seals often become caught in from gillnets when attempting to salmon that have been caught. For the Gulf of Alaska stock, the estimated minimum annual mortality rate incidental to commercial fisheries is 24 animals (Angliss and Allen 2008).

Subsistence Interactions— The MMPA restricts the hunting of harbor seals to Alaska Natives. In some areas, harbor seals are an important part of the subsistence economy. Angliss and Allen (2008) report that based on data from Alaska Department of Fish and Game for the years 2000 to 2004, the annual number of harbor seal taken from the Gulf of Alaska stock is 795 animals.

4.4.3 Northern Elephant Seal (*Mirounga angustirostris*)

Stock—California Breeding

Regulatory Status— T Northern elephant seals (*Mirounga angustirostris*) are not listed as threatened or endangered under the ESA or depleted under the MMPA. The California Breeding stock is not classified as strategic.

Habitat Preferences- Breeding and molting habitats for northern elephant seals are characterized by sandy beaches, mostly on offshore islands, but also in some mainland locations, along the coast. When on shore, seals will also use small coves and sand dunes behind and adjacent to breeding beaches. They rarely enter the water during the breeding season, but some seals will spend short periods in tide pools and alongshore; these are most commonly weaned pups that are learning to swim. Feeding habitat is mostly in deep, offshore waters of warm temperate to subpolar zones. Some seals will move into subtropical or tropical waters while foraging. (DoN 2006)

Population and Size Trends— The California Breeding stock of the northern elephant seal has recovered from near extinction in the early 1900s to an estimated 124,000 (Carretta et al., 2007b). Current census data suggest an increasing population trend. Although movement and genetic exchange continue between rookeries, most elephant seals return to their natal rookeries to breed. The California and Mexican Breeding groups may be demographically isolated and are currently considered two separate stocks. Individuals from the California Breeding stock do occur in the GOA, typically only sub-adult and adult male elephant seals forage in the GOA (Le Boeuf et al. 2000). The population size has to be estimated since all age classes are not ashore at any one time of the year. There are now at least 101,000 elephant seals in the California Breeding stock (Carretta et al. 2007), Numbers in this stock are increasing by around 6 percent annually (Stewart et al. 1994, Carretta et al. 2007). For purposes of acoustic impact modeling, a density of 0.0022/km^2 was derived for elephant seals in the TMAA as described in detail in Appendix B.

Distribution— Northern elephant seals are endemic to the North Pacific Ocean, occurring almost exclusively in the eastern and central North Pacific. Adult males range further north into the GOA and along the Aleutian Islands. Vagrant individuals do sometimes range to the western North Pacific. The most far-ranging known individual appeared on Nijima Island, off the Pacific coast of Japan in 1989 demonstrating the great distances these animals are capable of covering. (DoN 2006)

Adult males and females segregate while foraging and migrating (Stewart and DeLong 1995, Stewart 1997). Adult females mostly range east to about 173°W, between the latitudes of 40°N and 45°N remaining far to the west of the TMAA. In contrast, adult males range further north and east into the GOA and along the Aleutian Islands to between 47°N and 58°N (Stewart and Huber 1993, Stewart and DeLong 1995, Le Boeuf et. al. 2000). Northern elephant seal males regularly occur in the GOA year-round (Calkins 1986). Adults stay offshore during migration, while juveniles and subadults are often seen along the coasts of Oregon, Washington State, and British Columbia (Condit and Le Boeuf 1984, Stewart and Huber 1993). Females may cover over 18,000 km (11,185 mi) and males over 21,000 km (13049 mi) during these postbreeding migrations (Stewart and DeLong 1995). There are few records of northern elephant seals being present in southeast Alaska. (DoN 2006)

Life History— Northern elephant seals haul out on land to give birth and breed from December through March, and pups remain hauled out through April. After spending time at sea to feed (post-breeding migration), they generally return to the same areas to molt (Odell 1974, Stewart and Yochem 1984, Stewart and DeLong 1995). However, they do not necessarily return to the same beach. Adult males tend to haul out to molt between June and August (peaking in July), whereas females and juveniles haul out to most between March and May (peaking in April). Sub-adult and adult male northern elephant seals are found in the MAA predominately in the spring and fall (Le Boeuf et al. 2000). For much of the year, northern elephant seals feed mostly in deep, offshore waters, and their foraging range extends thousands of kilometers offshore from the breeding range into the eastern and central North Pacific (Stewart and DeLong 1995, Stewart 1997, Le Boeuf et al. 2000). Adult males and females segregate while foraging and migrating; females mostly range west to about 173°W, between the latitudes of 40°N and 45°N, whereas males range further north into the GOA and along the Aleutian Islands, to between 47°N and 58°N (Stewart and Huber 1993, Stewart and DeLong 1995, Le Boeuf et al. 2000).

Reproduction/Breeding— The elephant seal pupping/breeding season occurs from December through March on the rookeries in California and Mexico. There are no known areas used by elephant seals for reproduction or calving in the TMAA.

Diving Behavior— Details regarding the characterization of diving behavior for input into acoustic impact modeling for elephant seals are provided in Appendix B. Elephant seals are probably the deepest and longest diving pinnipeds; few other mammals can match their abilities. Adults dive continuously, day and night, during their feeding migrations. Elephant seals may spend as much as 90 percent of their time submerged; this year-round pattern of continuous, long, deep dives explains why northern elephant seals are rarely seen at sea and why their oceanic whereabouts and migrations have long been unknown. The average diving cycle consists of a 23-min dive, followed by a 2- to 4-min surface interval. The longest known dive is 106 min. Dives average between 1,148 and 1,805 ft (350 and 550 m) in depth and can reach as deep as 5,121 ft (1,561 m; females) and 5,200 ft (1,585 m; males). (DoN 2006)

Acoustics— Northern elephant seals produce loud, low-frequency in-air vocalizations. The mean fundamental frequencies are in the range of 147 to 334 Hz for adult males. The mean source level of the male produced vocalizations during the breeding season is 110 dB re 20 µPa. In-air calls made by aggressive males include (1) snoring, which is a low-intensity threat; (2) a snort (0.2 to 0.6 kHz) made by a dominant male when approached by a subdominant male; and (3) a clap threat (<2.5 kHz) which may contain signature information at the individual level. Seismic (low frequency) vibrations accompany these in-air vocalizations; they are produced as males move about and vocalize on sand beaches. These sounds appear to be important social cues. The mean fundamental frequency of airborne calls for adult females is 500 to 1,000 Hz. In-air sounds produced by females include a <0.7 kHz belch roar used in aggressive situations and a 0.5 to 1 kHz bark used to attract the pup. Pups use a <1.4 kHz call to maintain contact with the mother. Evidence for underwater sound production by this species is scant. Except for one unsubstantiated report, none have been definitively identified. (DoN 2006)

The audiogram of northern elephant seals indicates that this species is well-adapted for underwater hearing; sensitivity is best between 3.2 and 45 kHz (see Table 3.8-3), with greatest sensitivity at 6.4 kHz and an upper frequency cutoff of approximately 55 kHz. Elephant seals exhibit the greatest sensitivity to low frequency (<1 kHz) sound among seals in which hearing has been tested. In-air hearing is generally poor, but is best for frequencies between 3.2 and 15 kHz, with greatest sensitivity at 6.3 kHz. The upper frequency limit in air is approximately 20 kHz. Elephant seals are relatively good at detecting tonal signals over masking noise. (DoN 2006)

Impacts of Human Activity

Fisheries Interactions— Stranding data reported to the California, Oregon, and Washington Marine Mammal stranding Networks in 2000-2004 include elephant seal injuries caused by hook-and-line fisheries (two injuries) and gillnet fisheries (one injury). The estimated mortality and serious injury of northern elephant seals (California Breeding stock) in commercial fisheries that might take this species is less than 8.8 animals per year. (Carretta et al. 2007b)

Other Interactions— Stranding databases for California, Oregon, and Washington states that are maintained by NMFS contain the following records of human-related elephant seal mortalities and injuries in 2000-2004: (1) boat collisions (3 mortalities), (2) power plant entrainment (1 mortality), (3) shootings (4 mortalities), and (4) entanglement in marine debris (10 mortalities). This results in a minimum annual average of 1.6 nonfishery related mortalities for 2000-2004. (Carretta et al. 2007b)

4.4.4 Northern Fur Seal (*Callorhinus ursinus*)

Stock—Eastern Pacific

Regulatory Status— The northern fur seal is not listed as threatened or endangered under the ESA. The Eastern Pacific stock of northern fur seal is classified as a strategic stock because it is designated as depleted under the MMPA.

Habitat Preferences- Northern fur seals are a highly oceanic species spending all but 35 to 45 days per year at sea. They are usually sighted 38 to 70 nm (70 to 130 km) from land along the continental shelf and slope, seamounts, submarine canyons, and sea valleys, where there are upwellings of nutrient-rich water. The Pribilof Islands in the Bering Sea are the rookery location for most of the worldwide population during the summer breeding season (Angliss and Allen 2008). Following the breeding season, most females and juveniles migrate south to waters off British Columbia, Washington, Oregon, and California, and most adult males remain in the GOA (DoN 2006).

Population Size and Trends— Two stocks of northern fur seals are recognized in U.S. waters: an Eastern Pacific stock and a San Miguel Island stock. The Eastern Pacific stock includes the Pribilof Island breeding group in the Bering Sea. The most recent population estimate for the Eastern Pacific stock is 665,550 (Angliss and Allen, 2008). In 1999, the population began to recover, and by 2002 the total pup count was 1,946 (Carretta et al., 2007b). It is a “strategic” stock because it is considered “depleted” under the MMPA because the population has declined from the 1.8 million animals estimated in the 1950s (Angliss and Outlaw 2006). For purposes of acoustic impact modeling, a density of $0.1180/km^2$ was derived for northern fur seals in the TMAA as described in detail in Appendix B.

Distribution— Northern fur seals occur from Southern California north to the Bering Sea and west to the Okhotsk Sea and Honshu Island, Japan (Carretta et al., 2006). They are a coldwater species and when at sea they are usually sighted in forage areas along the continental shelf and slope 38 to 70 nm (70 to 130 km) from land and along the continental shelf and slope where they typically forage (Kajimura 1984). The Eastern Pacific stock spends May–November in northern waters and at northern breeding colonies (north of the GOA). In late November, females and young begin to arrive in offshore waters of California, with some animals moving south into continental shelf and slope waters. Adult males from the Eastern Pacific stock generally migrate only as far south as the GOA (Kajimura 1984). Maximum numbers are found in the southern extent of their range in waters from 42ºN to 34ºN during February–April. By early June, most seals of the Eastern Pacific stock have migrated back to northern waters (Antonelis and Fiscus 1980).

Peak abundance in the TMAA should occur between March and June during the annual migration north to the Pribilof Islands breeding grounds (Fiscus et al. 1976, Consiglieri et al. 1982). Tagging data presented by Ream et al. (2005) indicate the main foraging areas and the main migration route through the GOA are located far to the west of the TMAA. There are no rookeries or haulout sites in the vicinity of the TMAA. Some northern fur seals, particularly juvenile males and nonpregnant females, remain in the GOA throughout the summer and have been documented in the nearshore waters of Southeastern Alaska, Prince William Sound, Portlock Bank, and the middle of the GOA (Calkins 1986, Fiscus et al. 1976). (DoN 2006) The 2009 GOALS survey (Rone et al. 2009) did not encounter any northern fur seals in the TMAA although the acoustic analysis assumes they are the second-most abundant marine mammal in the area. It is likely, therefore, that effects from Navy activities on this species in this analysis are an overestimate.

Life History— Northern fur seals are solitary at sea but tend to congregate in food-rich areas where as many as 100 individuals have been sighted (Antonelis and Fiscus 1980, Kajimura 1984). Northern fur seals feed opportunistically on a variety of fish and squids species throughout their range (Kajimura, 1984). Northern fur seals are gregarious during the breeding season and maintain a complex social structure on the rookeries. The largest rookery is on St. Paul and St. George Islands in the Pribilof Islands Archipelago in Alaska. Smaller breeding colonies are located on the Kuril Islands, Robben Island, and the Commander Islands in Russia; Bogoslof Island in the southeastern Bering Sea; and San Miguel and the Farallon Islands in California (Pyle et al. 2001, Robson 2002).

Reproduction/Breeding— Pupping and breeding occur between June and August on the Pribilof Islands (York, 1987). Pups are weaned at around 4 months (Gentry, 1998). There are no known areas used by Northern fur seals for reproduction or calving in the TMAA.

Diving Behavior— Details regarding the characterization of diving behavior for input into acoustic impact modeling for northern fur seals are provided in Appendix B. Northern fur seals are solitary at sea but tend to congregate in food-rich areas where as many as 100 individuals have been sighted. The average dive time for northern fur seals is 2.6 min, with a maximum between 5 and 7 min. The deepest recorded dive is 679 ft (207 m), but most are between 66 and 459 ft (20 and 140 m) and are probably associated with feeding. (DoN 2006)

Acoustics— Northern fur seals produce underwater clicks, and in-air bleating, barking, coughing, and roaring sounds. Males vocalize (roar) almost continuously at rookeries. Females and pups produce airborne sounds (bawls) to reunite after separation. The hearing ability of this species has been measured in air and underwater by behavioral methods. (DoN 2006)

Of all the pinniped species for which hearing information is available, northern fur seals are the most sensitive to airborne sound. In air, this species can hear sounds ranging from 0.1 to 36 kHz, with best sensitivity from 2 to 16 kHz. There is an anomalous in-air hearing loss at around 4 or 5 kHz, which is attributed to a middle specialization. The underwater hearing range of northern fur seals ranges from 0.5 Hz to 40 kHz (most sensitive from 2 to 32 kHz). The underwater hearing sensitivity of this species is 15 to 20 dB better than in the air. (DoN 2006)

Impacts of Human Activity

Fisheries Interactions— The estimated mortality and serious injury of northern fur seals in commercial fisheries that might take this species is approximately 1.9 animals per year. (Angliss and Allen 2008)

Subsistence Interaction— Alaska Natives residing on the Pribilof Islands are allowed an annual subsistence harvest of northern fur seals, with a take range determined from annual household surveys. Between 2001 and 2006, there was an annual average of 667 seals harvested per year. (Angliss and Allen 2008)

Other Interactions— Mortality resulting from entanglement in marine debris has been implicated as a contributing factor in the previous decline of Eastern Pacific stock of northern fur seal. The average entanglement rate for adult males from 1998 to 2002 was 0.27 percent (Angliss and Allen 2008), and if that rate was sustained, the result would be approximately 1,900 mortalities to male fur seals based on the current minimum population estimate.

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5 HARASSMENT AUTHORIZATION REQUESTED

The Navy requests a Letter of Authorization (LOA) pursuant to Section 101 (a)(5)(A) of the Marine Mammal Protection Act (MMPA) for harassment of marine mammals incidental to Navy training in the Gulf of Alaska (GOA) Temporary Maritime Activities Area (TMAA). The authorization requested is for the incidental harassment of marine mammals under the MMPA due to MMPA Level B harassment and the potential for mortality. It is understood that an LOA is applicable for up to 5 years, and is appropriate where authorization for potential injury (MMPA Level A harassment) or mortality of marine mammals is requested in addition to incidental MMPA Level B harassment. The request is for exercises and training events conducted within the GOA TMAA. These include activities that use active mid-frequency and high-frequency sonar or involve explosive sources. This request is for a 5-year period commencing in September 2010.

The acoustic modeling approach taken in the GOA Environmental Impact Statement/Overseas Environmental Impact Statement (EIS/OEIS) and this LOA request attempts to quantify potential exposures to marine mammals resulting from the use of mid-frequency active (MFA) and high-frequency active (HFA) sonar and at-sea explosions. Results from this modeling approach are presented without consideration of mitigation measures employed per Navy standard operating procedures. For example, securing or turning off an active sonar when an animal approaches closer than a specified distance reduces potential exposure since the sonar is no longer transmitting. Range clearance procedures and safety requirements having long set-up times for events using explosives also make it very unlikely any marine mammals will be in the vicinity of most events, including at-sea explosives, undetected.

Neither the National Marine Fisheries Service (NMFS) nor the Navy anticipates that marine mammal strandings or indirectly caused mortality will result from the use of mid- or high-frequency sonar during Navy exercises within the TMAA. However, during the MMPA process (which allows for adaptive management), NMFS and the Navy will determine the appropriate way to proceed in the unlikely event that a causal relationship were to be found between Navy activities and a future stranding.

MMPA Level B harassment in the context of military readiness activities is defined as 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. The estimate of total predicted marine mammal sound exposures potentially constituting MMPA Level B harassment is presented in this analysis is without consideration of standard Navy mitigation measures. In addition, the assessment of whether temporary physiological effects or behavioral responses may cause behavioral patterns to be abandoned or significantly altered is considered in the context of an analytical framework for active sonar. As noted previously, only a subset of predicted exposures are likely to result in Level B harassment and it is assumed that multiple exposures to the same individual marine mammal would have a higher likelihood of disturbance than single exposures. Given, however, the constant movement of vessels and aircraft during training events, especially those involving active sonar, and the large size of the TMAA, multiple exposures to the same individual marine mammals are very unlikely.

Although Navy Anti-Submarine Warfare (ASW) training has not been a part of past actions in the TMAA, there is a long history of intensive training activities having taken place in Southern California, Hawaii, the Pacific Northwest, and along the Atlantic coast in Navy concentration areas. Based on the long history of conducting those ongoing activities using the same basic equipment in the same general areas for decades without any indications of effects to marine mammals, the incidental harassment of marine mammals associated with the proposed Navy training in the TMAA is expected to have no more than negligible impacts on marine mammal species or stocks. The predicted exposures that result in behavioral reactions should be no more than temporary alterations of behavior. There should be no direct physiological effects resulting in injury and no effects to proximate marine mammal life functions.

The modeling analysis, used to estimate the maximum number of marine mammals that could be exposed annually by Navy training using active sonar, will overestimate the potential effects given there has been no attempt to quantify reductions in the estimate based on implementation of standard Navy mitigation measures. Modeling for active sonar use associated with the proposed training activities indicates a total of 425,551 marine mammals could be exposed to levels of sonar that NMFS may consider MMPA Level B harassment under the MMPA for military readiness activities (Table 5-1). Within this total, 424,620 marine mammals could be exposed to Navy training events resulting in non-temporary threshold shift (TTS) MMPA Level B harassment from behavioral disturbance that NMFS may consider Level B harassment under the MMPA for military readiness activities. The modeling indicates 931 MMPA Level B sonar exposures that exceed the regulatory threshold indicative of the TTS, which is also considered MMPA Level B harassment.

Table 5-1. MMPA Level B Harassment Exposures

Source	Criteria	Level B Exposures
Sonar & non-Sonar Acoustic Sources	Non-TTS (Risk Function)	424,620
	TTS	931
	Sonar and non-Sonar Exposures Sub-Total	425,551
At-Sea Explosive	Sub-TTS (multiple successive explosions)	170
	TTS	70
	At-Sea Explosives Exposures Sub-Total	240
	Total Level B	425,791

Notes: MMPA = Marine Mammal Protection Action TTS = Temporary Threshold Shift

Acoustic exposure modeling indicates one exposure (a summation of partial exposures across all sonar training events that rounds up to one) for Dall's porpoise that exceeds the regulatory threshold for permanent threshold shift (MMPA Level A harassment); however, this one exposure is not likely to occur given the Navy's standard mitigation measures and the short distance between the source and marine mammal for this exposure to occur. The Navy is not requesting authorization for this one MMPA Level A harassment as a result of sonar use.

For at-sea explosions associated with the proposed training activities and without taking Navy area clearance procedures into account, modeling indicates 240 marine mammals may be exposed to impulsive noise or pressure from at-sea explosions that could result in "behavioral modification" (MMPA Level B harassment) (Table 5-1). Within this total the estimate includes 170 sub-TTS MMPA Level B harassment exposures from multiple successive explosions (MSEs) and 70 MMPA Level B harassment exposures indicative of TTS.

Modeling for at-sea explosions also indicates four marine mammals could be exposed to impulsive noise from at-sea explosions that could result in a Permanent Threshold Shift (PTS) indicative of injury (MMPA Level A harassment). Given area clearance procedures in the vicinity of events involving at-sea explosions and implementation of standard mitigation measures, the Navy believes that these four estimated exposures should not occur. Navy is not requesting authorization for these four MMPA Level A harassments.

Modeling indicates one exposure (a summation of partial exposures across all MK-82 at-sea explosion training events rounding up to one) for Dall's porpoise that exceeds the 31-pounds per square inch per millisecond (psi-ms) regulatory threshold for onset extensive lung injury or mortality. This one exposure is not likely to occur given area clearance procedures, the Navy's standard mitigation measures, and the short distance between the source and marine mammal for this level of exposure to occur. The Navy is not requesting authorization for this one injury or mortality since it should not occur.

In addition to the quantified modeling results, NMFS previously indicated in a letter to the Navy dated October 2006, that Section 101(a)(5)(A) authorization is appropriate for MFA/HFA sonar activities because it allows NMFS to consider the potential for incidental mortality. NMFS' letter indicated, "Because mid-frequency sonar has been implicated in several marine mammal stranding events including some involving serious injury and mortality, and because there is no scientific consensus regarding the causal link between sonar and stranding events, NMFS cannot conclude with certainty the degree to which mitigation measures would eliminate or reduce the potential for serious injury or mortality."

There are five beaked whale mass strandings that have been temporally and spatially associated with military training events using MFA sonar. These events over an 11-year period represent a small overall number of animals (40 animals; Podesta et al., 2006). Four of the five events occurred during NATO exercises or events where Department of the Navy presence was limited (Greece, Portugal, Canary Islands, and Spain). One of the five events involved only Department of the Navy ships (Bahamas).

Given the frequency of naturally occurring marine mammal strandings in the GOA, it is conceivable that a beaked whale stranding could co-occur with Navy training activities even though the stranding is actually unrelated to and not caused by those activities. Accordingly, the Navy is requesting take, by mortality, of three beaked whales annually, based on the three known species of beaked whales present in the TMAA (Baird's, Cuvier's, and Stejneger's beaked whale).

In all cases, the conclusions are that Level B harassment to a small number of marine mammals would have a negligible impact on marine mammal species or stocks. This interpretation of the modeling estimates apply to all marine mammal species in the TMAA for the following reasons:

- The decades long history of sonar training activities in Navy concentration areas (i.e., Hawaii, southern California) without any indications of effect to marine mammal stocks or species.
- The widely dispersed geography of the activities in the TMAA and evaluation of the potential for physiological and behavioral disturbance.
- The limitation of total duration of activities to two 21-day (maximum) exercise periods.
- The reduction of potential effects attributed to the Navy's standard mitigation measures.

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6 NUMBER OF SPECIES EXPOSED

6.1 ACOUSTIC EFFECTS

6.1.1 ASSESSING MARINE MAMMAL RESPONSES TO SONAR

As summarized by the National Academies of Science (NAS), the possibility that human-generated sound could harm marine mammals or significantly interfere with their "normal" activities has been an issue of concern (National Research Council [NRC] 2005). This section of the authorization request evaluates the potential quantification for specific Navy acoustic sources proposed for use in the Gulf of Alaska (GOA) Temporary Maritime Activities Area (TMAA) to result in harassment of or injury to marine mammals.

Assessing whether a sound may disturb or injure a marine mammal involves understanding the characteristics of the acoustic sources, the marine mammals that may be present in the vicinity of the sound, and the effects that sound may have on the physiology and behavior of those marine mammals. Although it is known that sound is important for marine mammal communication, navigation, and foraging (NRC 2003, NRC 2005), there are many unknowns in assessing the effects and significance of marine mammal responses to sound exposures related to the context for the exposure and the disposition of the marine mammal (Southall et al. 2007). For this reason, the Navy enlisted the expertise of NMFS as a cooperating agency. Their input assisted the Navy in developing a conceptual analytical framework for evaluating what sound levels marine mammals might receive as a result of Navy training actions, whether marine mammals might respond to these exposures, and whether that response might have a mode of action on the biology or ecology of marine mammals such that the response should be considered a potential harassment. From this framework of evaluating the potential for harassment incidents to occur, an assessment of whether acoustic sources might impact populations, stocks or species of marine mammals can be conducted.

The flow chart in Figure 6-1 is a representation of the general analytical framework utilized in applying the specific thresholds discussed in this section. The framework presented in the flow chart is organized from left to right and is compartmentalized according to the phenomena that occur within each. These include the physics of sound propagation (Physics), the potential physiological processes associated with sound exposure (Physiology), the potential behavioral processes that might be affected as a function of sound exposure (Behavior), and the immediate effects these changes may have on functions the animal is engaged in at the time of exposure (Life Function – Proximate). These compartmentalized effects are extended to longer term life functions (Life Function – Ultimate) and into population and species effects.

Throughout the flow chart, dotted and solid lines are used to connect related events. Solid lines designate those effects that "will" happen; dotted lines designate those that "might" happen but must be considered (including those hypothesized to occur but for which there is no direct evidence).

Some boxes contained within the flow chart are colored according to how they relate to the definitions of harassment in the MMPA. Red boxes correspond to events that are injurious. By prior ruling and usage, these events would be considered as Level A harassment under the MMPA. Yellow boxes correspond to events that have the potential to qualify as Level B harassment under the MMPA. Based on prior ruling, the specific instance of Temporary Threshold Shift (TTS) is considered as part of Level B harassment (Level B harassment includes TTS, non-TTS, and sub-TTS). Boxes that are shaded from red to yellow have the potential for injury (Level A harassment) and behavioral disturbance (Level B harassment).

The analytical framework outlined within the flow chart acknowledges that physiological responses must always precede behavioral responses (i.e., there can be no behavioral response without first some physiological effect of the sound) and an organization where each functional block only occurs once and all relevant inputs/outputs flow to/from a single instance.

6.1.1.1 Physics

Starting with a sound source, the attenuation of an emitted sound due to propagation loss is determined. Uniform animal distribution is overlaid onto the calculated sound fields to assess if animals are physically present at sufficient received sound levels to be considered "exposed" to the sound. If the animal is determined to be exposed, two possible scenarios must be considered with respect to the animal's physiology – effects on the auditory system and effects on nonauditory system tissues. These are not independent pathways and both must be considered since the same sound could affect both auditory and nonauditory tissues. Note that the model does not account for any animal response; rather the animals are considered stationary, accumulating energy until the threshold is tripped.

6.1.1.2 Physiology

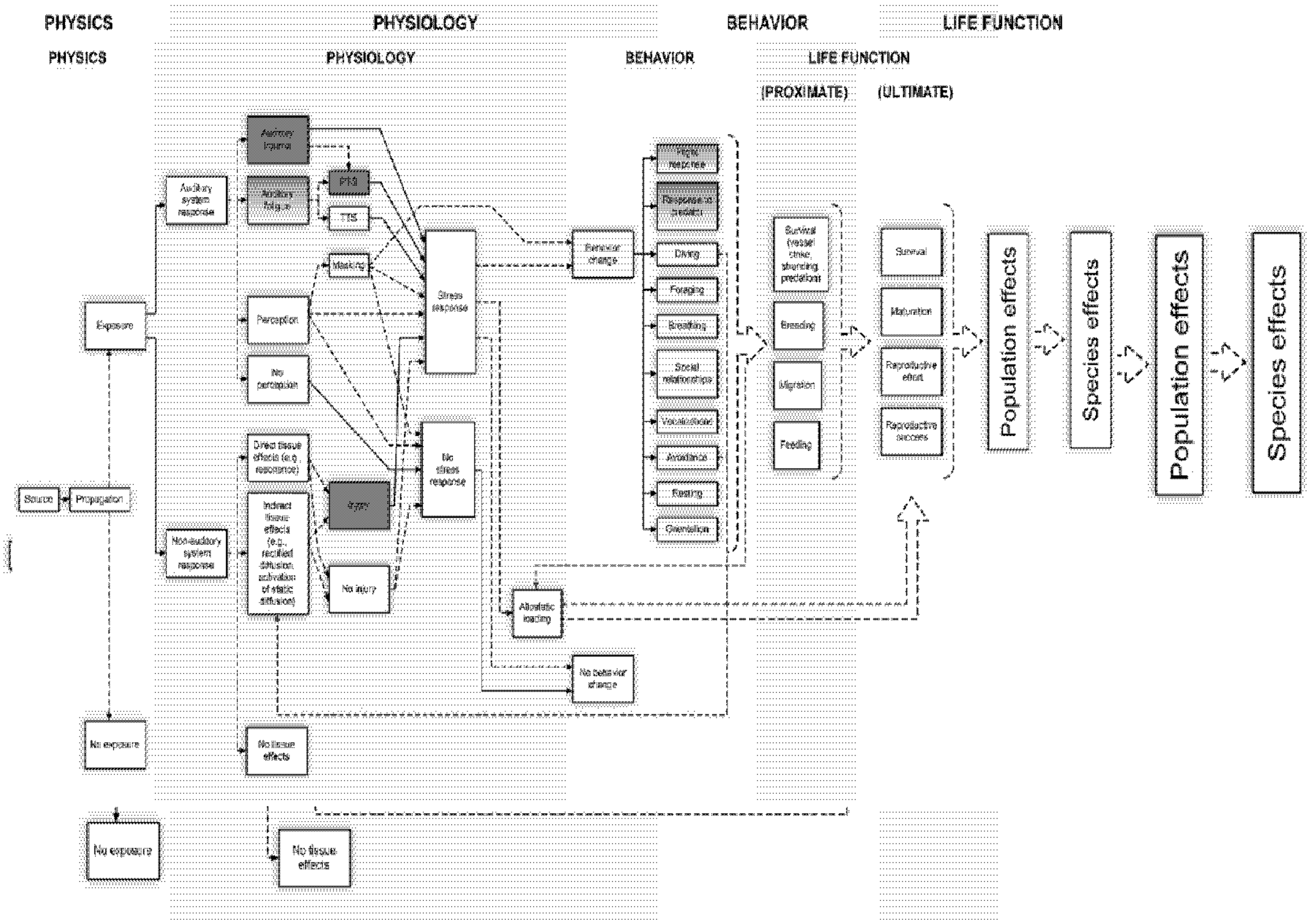
Potential impacts to the auditory system are assessed by considering the characteristics of the received sound (e.g., amplitude, frequency, duration) and the sensitivity of the exposed animals. Some of these assessments can be numerically based (e.g., TTS, Permanent Threshold Shift [PTS], perception). Others will be necessarily qualitative, due to lack of information, or will need to be extrapolated from other species for which information exists. Potential physiological responses to the sound exposure are ranked in descending order, with the most severe impact (auditory trauma) occurring at the top and the least severe impact occurring at the bottom (the sound is not perceived).

1. Auditory trauma represents direct mechanical injury to hearing related structures, including tympanic membrane rupture, disarticulation of the middle ear ossicles, and trauma to the inner ear structures such as the organ of Corti and the associated hair cells. Auditory trauma is always injurious but could be temporary and not result in PTS. Auditory trauma is always assumed to result in a stress response.

2. Auditory fatigue refers to a loss of hearing sensitivity after sound stimulation. The loss of sensitivity persists after, sometimes long after, the cessation of the sound. The mechanisms responsible for auditory fatigue differ from auditory trauma and would primarily consist of metabolic exhaustion of the hair cells and cochlear tissues. The features of the exposure (e.g., amplitude, frequency, duration, temporal pattern) and the individual animal's susceptibility would determine the severity of fatigue and whether the effects were temporary (TTS) or permanent (PTS). Auditory fatigue (PTS or TTS) is always assumed to result in a stress response.

3. Sounds with sufficient amplitude and duration to be detected among the background ambient noise are considered to be perceived. This category includes sounds from the threshold of audibility through the normal dynamic range of hearing (i.e., not capable of producing fatigue). To determine whether an animal perceives the sound, the received level, frequency, and duration of the sound are compared to what is known of the species' hearing sensitivity.

Since audible sounds may interfere with an animal's ability to detect other sounds at the same time, perceived sounds have the potential to result in auditory masking. Unlike auditory fatigue, which always results in a stress response because the sensory tissues are being stimulated beyond their normal physiological range, masking may or may not result in a stress response, depending on the degree and duration of the masking effect. Masking may also result in a unique circumstance where an animal's ability to detect other sounds is compromised without the animal's knowledge. This could conceivably result in sensory impairment and subsequent behavior change; in this case, the change in behavior is the *lack of a response* that would normally be made if sensory impairment did not occur. For this reason, masking also may lead directly to behavior change without first causing a stress response.



1 **Figure 6-1. Conceptual Model for Assessing Effects fo Mid-Frequency Active Sonar Exposures on Marine Mammals**

The features of perceived sound (e.g., amplitude, duration, temporal pattern) are also used to judge whether the sound exposure is capable of producing a stress response. Factors to consider in this decision include the probability of the animal being naïve or experienced with the sound (i.e., what are the known/unknown consequences of the exposure).

The received level is not of sufficient amplitude, frequency, and duration to be perceptible by the animal. By extension, this does not result in a stress response (not perceived).

Potential impacts to tissues other than those related to the auditory system are assessed by considering the characteristics of the sound (e.g., amplitude, frequency, duration) and the known or estimated response characteristics of nonauditory tissues. Some of these assessments can be numerically based (e.g., exposure required for rectified diffusion). Others will be necessarily qualitative, due to lack of information. Each of the potential responses may or may not result in a stress response.

1. Direct tissue effects – Direct tissue responses to sound stimulation may range from tissue shearing (injury) to mechanical vibration with no resulting injury. Any tissue injury would produce a stress response, whereas noninjurious stimulation may or may not.

2. Indirect tissue effects – Based on the amplitude, frequency, and duration of the sound, it must be assessed whether exposure is sufficient to indirectly affect tissues. For example, the hypothesis that rectified diffusion occurs is based on the idea that bubbles that naturally exist in biological tissues can be stimulated to grow by an acoustic field. Under this hypothesis, one of three things could happen: (1) bubbles grow to the extent that tissue hemorrhage occurs (injury); (2) bubbles develop to the extent that a complement immune response is triggered or nervous tissue is subjected to enough localized pressure that pain or dysfunction occurs (a stress response without injury); or (3) the bubbles are cleared by the lung without negative consequence to the animal. The probability of rectified diffusion, or any other indirect tissue effect, will necessarily be based on what is known about the specific process involved.

3. No tissue effects – The received sound is insufficient to cause either direct mechanical) or indirect effects to tissues. No stress response occurs.

The Stress Response

The acoustic source is considered a potential stressor if, by its action on the animal, via auditory or nonauditory means, it may produce a stress response in the animal. The term "stress" has taken on an ambiguous meaning in the scientific literature, but with respect to the discussions of allostasis and allostatic loading, the stress response will refer to an increase in energetic expenditure that results from exposure to the stressor and which is predominantly characterized by either the stimulation of the sympathetic nervous system (SNS) or the hypothalamic-pituitary-adrenal (HPA) axis (Reeder and Kramer 2005).

The presence and magnitude of a stress response in an animal depends on a number of factors. These include the animal's life history stage (e.g., neonate, juvenile, adult), the environmental conditions, reproductive or developmental state, and experience with the stressor.

Not only will these factors be subject to individual variation, but they will also vary within an individual over time. Prior experience with a stressor may be of particular importance as repeated experience with a stressor may dull the stress response via acclimation (St. Aubin and Dierauf, 2001). In considering potential stress responses of marine mammals to acoustic stressors, each of these should be considered. For example, is the acoustic stressor in an area where animals engage in breeding activity? Are animals in the region resident and likely to have experience with the stressor (i.e., repeated exposures)? Is the region a foraging ground or are the animals passing through as transients? What is the ratio of young (naïve) to old (experienced) animals in the population? It is unlikely that all such questions can be answered from empirical data; however, they should be addressed in any qualitative assessment of a potential stress response as based on the available literature.

Marine mammals naturally experience stressors within their environment and as part of their life histories. Changing weather and ocean conditions, exposure to diseases and naturally occurring toxins, lack of prey availability, social interactions with conspecifics, and interactions with predators all contribute to the stress a marine mammal experiences. In some cases, naturally occurring stressors can have profound impacts on marine mammals; for example, chronic stress, as observed in stranded animals with long-term debilitating conditions (e.g., disease), has been demonstrated to result in an increased size of the adrenal glands and an increase in the number of epinephrine-producing cells (Clark et al. 2006). Anthropogenic activities have the potential to provide additional stressors above and beyond those that occur naturally. Potential stressors resulting from anthropogenic activities must be considered not only as to their direct impact on the animal but also as to their cumulative impact with environmental stressors already experienced by the animal.

Studies on the stress response of odontocete cetaceans to acute acoustic stimuli were previously discussed Thomas et al., 1990, Miksis et al., 2001, Romano et al. 2004). Other types of stressors include the presence of vessels, fishery interactions, acts of pursuit and capture, the act of stranding, and pollution. In contrast to the limited amount of work performed on stress responses resulting from sound exposure, a considerably larger body of work exists on stress responses associated with pursuit, capture, handling and stranding. Pursuit, capture and short-term holding of belugas has been observed to result in a decrease in thyroid hormones (St. Aubin and Geraci 1988) and increases in epinephrine (St. Aubin and Dierauf, 2001). In dolphins, the trend is more complicated with the duration of the handling time potentially contributing to the magnitude of the stress response (St. Aubin et al. 1996, Ortiz and Worthy 2000, St. Aubin 2002). Elephant seals demonstrate an acute cortisol response to handling, but do not demonstrate a chronic response; on the contrary, adult females demonstrate a reduction in the adrenocortical response following repetitive chemical immobilization (Engelhard et al. 2002). With respect to anthropogenic sound as a stressor, the current limited body of knowledge will require extrapolation from species for which information exists to those for which no information exists.

The stress response may or may not result in a behavioral change, depending on the characteristics of the exposed animal. However, provided a stress response occurs, we assume that some contribution is made to the animal's allostatic load. Allostasis is the ability of an animal to maintain stability through change by adjusting its physiology in response to both predictable and unpredictable events (McEwen and Wingfield 2003). The same hormones associated with the stress response vary naturally throughout an animal's life, providing support for particular life history events (e.g., pregnancy) and predictable environmental conditions (e.g., seasonal changes). The allostatic load is the cumulative cost of allostasis incurred by an animal and is generally characterized with respect to an animal's energetic expenditure. Perturbations to an animal that may occur with the presence of a stressor, either biological (e.g., predator) or anthropogenic (e.g., construction), can contribute to the allostatic load (McEwen and Wingfield 2003). Additional costs are cumulative and additions to the allostatic load over time may contribute to reductions in the probability of achieving ultimate life history functions (e.g., survival, maturation, reproductive effort and success) by producing pathophysiological states. The contribution to the allostatic load from a stressor requires estimating the magnitude and duration of the stress response, as well as any secondary contributions that might result from a change in behavior.

If the acoustic source does not produce tissue effects, is not perceived by the animal, or does not produce a stress response by any other means, Figure 6-1 assumes that the exposure does not contribute to the allostatic load. Additionally, without a stress response or auditory masking, it is assumed that there can be no behavioral change. Conversely, any immediate effect of exposure that produces an injury (i.e., red boxes on the flow chart in Figure 6-1) is assumed to also produce a stress response and contribute to the allostatic load.

6.1.1.3 Behavior

Acute stress responses may or may not cause a behavioral reaction. However, all changes in behavior are expected to result from an acute stress response. This expectation is based on the idea that some sort of physiological trigger must exist to change any behavior that is already being performed. The exception to this rule is the case of masking. The presence of a masking sound may not produce a stress response, but may interfere with the animal's ability to detect and discriminate biologically relevant signals. The inability to detect and discriminate biologically relevant signals hinders the potential for normal behavioral responses to auditory cues and is thus considered a behavioral change.

Numerous behavioral changes can occur as a result of stress response, and Figure 3.8-3 lists only those that might be considered the most common types of response for a marine animal. For each potential behavioral change, the magnitude in the change and the severity of the response needs to be estimated. Certain conditions, such as stampeding (i.e., flight response) or a response to a predator, might have a probability of resulting in injury. For example, a flight response, if significant enough, could produce a stranding event. Under the MMPA, such an event would be considered a MMPA Level A harassment. Each altered behavior may also have the potential to disrupt biologically significant events (e.g., breeding or nursing) and may need to be qualified as MMPA Level B harassment. Exposures to sonar resulting in non-TTS behavioral disturbance and exposure to at-sea explosions resulting in sub-TTS behavioral disturbance are quantified as MMPA Level B harassment. All behavioral disruptions have the potential to contribute to the allostatic load. This secondary potential is signified by the feedback from the collective behaviors to allostatic loading (physiology block).

The response of a marine mammal to an anthropogenic sound source will depend on the frequency content, duration, temporal pattern and amplitude of the sound as well as the animal's prior experience with the sound and the context in which the sound is encountered (i.e., what the animal is doing at the time of the exposure). The direction of the responses can vary, with some changes resulting in either increases or decreases from baseline (e.g., decreased dive times and increased respiration rate). Responses can also overlap; for example, an increased respiration rate is likely to be coupled to a flight response. Differential responses between and within species are expected since hearing ranges vary across species and the behavioral ecology of individual species is unlikely to completely overlap.

A review of marine mammal responses to anthropogenic sound was first conducted by Richardson and others in 1995. A more recent review (Nowacek et al. 2007) addresses studies conducted since 1995 and focuses on observations where the received sound level of the exposed marine mammal(s) was known or could be estimated. The following sections provide a very brief overview of the state of knowledge of behavioral responses. The overviews focus on studies conducted since 2000 but are not meant to be comprehensive; rather, they provide an idea of the variability in behavioral responses that would be expected given the differential sensitivities of marine mammal species to sound and the wide range of potential acoustic sources to which a marine mammal may be exposed. Estimates of the types of behavioral responses that could occur for a given sound exposure should be determined from the literature that is available for each species, or extrapolated from closely related species when no information exists.

Flight Response

A flight response is a dramatic change in normal movement to a directed and rapid movement away from the perceived location of a sound source. Relatively little information on flight responses of marine mammals to anthropogenic signals exists, although observations of flight responses to the presence of predators have occurred (Connor and Heithaus 1996). Flight responses have been speculated as being a component of marine mammal strandings associated with sonar activities (Evans and England 2001).

Response to Predators

Evidence suggests that at least some marine mammals have the ability to acoustically identify potential predators. For example, harbor seals that reside in the coastal waters off British Columbia are frequently targeted by certain groups of killer whales, but not others. The seals discriminate between the calls of threatening and non-threatening killer whales (Deecke et al. 2002), a capability that should increase survivorship while reducing the energy required for attending to and responding to all killer whale calls. The occurrence of masking or hearing impairment provides a means by which marine mammals may be prevented from responding to the acoustic cues produced by their predators. Whether or not this is a possibility depends on the duration of the masking/hearing impairment and the likelihood of encountering a predator during the time that predator cues are impeded.

Diving

Changes in dive behavior can vary widely. They may consist of increased or decreased dive times and surface intervals as well as changes in the rates of ascent and descent during a dive. Variations in dive behavior may reflect interruptions in biologically significant activities (e.g., foraging) or they may be of little biological significance. Variations in dive behavior may also expose an animal to potentially harmful conditions (e.g., increasing the chance of ship-strike) or may serve as an avoidance response that enhances survivorship. The impact of a variation in diving resulting from an acoustic exposure depends on what the animal is doing at the time of the exposure and the type and magnitude of the response.

Nowacek et al. (2004) reported disruptions of dive behaviors in foraging North Atlantic right whales when exposed to an alerting stimulus, an action, they noted, that could lead to an increased likelihood of ship strike. However, the whales did not respond to playbacks of either right whale social sounds or vessel noise, highlighting the importance of the sound characteristics in producing a behavioral reaction. Conversely, Indo-Pacific humpback dolphins have been observed to dive for longer periods of time in areas where vessels were present and/or approaching (Ng and Leung 2003). In both of these studies, the influence of the sound exposure cannot be decoupled from the physical presence of a surface vessel, thus complicating interpretations of the relative contribution of each stimulus to the response. Indeed, the presence of surface vessels, their approach and speed of approach, seemed to be significant factors in the response of the Indo-Pacific humpback dolphins (Ng and Leung 2003). Low frequency signals of the Acoustic Thermometry of Ocean Climate (ATOC) sound source were not found to affect dive times of humpback whales in Hawaiian waters (Frankel and Clark 2000) or to overtly affect elephant seal dives (Costa et al. 2003). They did, however, produce subtle effects that varied in direction and degree among the individual seals, illustrating the equivocal nature of behavioral effects and consequent difficulty in defining and predicting them.

Due to past incidents of beaked whale strandings associated with sonar operations, feedback paths are provided between avoidance and diving and indirect tissue effects. This feedback accounts for the hypothesis that variations in diving behavior and/or avoidance responses can possibly result in nitrogen tissue supersaturation and nitrogen off-gassing, possibly to the point of deleterious vascular bubble formation (Jepson et al. 2003). Although hypothetical, the potential process is being debated within the scientific community.

Foraging

Disruption of feeding behavior can be difficult to correlate with anthropogenic sound exposure, so it is usually inferred by observed displacement from known foraging areas, the appearance of secondary indicators (e.g., bubble nets or sediment plumes), or changes in dive behavior. Noise from seismic surveys was not found to impact the feeding behavior in western gray whales off the coast of Russia (Yazvenko et al. 2007) and sperm whales engaged in foraging dives did not abandon dives when exposed to distant signatures of seismic airguns (Madsen et al. 2006). Balaenopterid whales exposed to moderate low-frequency signals similar to the ATOC sound source demonstrated no variation in foraging activity

(Croll et al. 2001), whereas five out of six North Atlantic right whales exposed to an acoustic alarm interrupted their foraging dives (Nowacek et al. 2004). Although the received sound pressure level at the animals was similar in the latter two studies, the frequency, duration, and temporal pattern of signal presentation were different. These factors, as well as differences in species sensitivity, are likely contributing factors to the differential response. A determination of whether foraging disruptions incur fitness consequences will require information on or estimates of the energetic requirements of the individuals and the relationship between prey availability, foraging effort and success, and the life history stage of the animal.

Breathing

Variations in respiration naturally vary with different behaviors and variations in respiration rate as a function of acoustic exposure can be expected to co-occur with other behavioral reactions, such as a flight response or an alteration in diving. However, respiration rates in and of themselves may be representative of annoyance or an acute stress response. Mean exhalation rates of gray whales at rest and while diving were found to be unaffected by seismic surveys conducted adjacent to the whale feeding grounds (Gailey et al., 2007). Studies with captive harbor porpoises showed increased respiration rates upon introduction of acoustic alarms (Kastelein et al. 2000, Kastelein et al. 2006a) and emissions for underwater data transmission (Kastelein et al. 2005). However, exposure of the same acoustic alarm to a striped dolphin under the same conditions did not elicit a response (Kastelein et al. 2006a), again highlighting the importance in understanding species differences in the tolerance of underwater noise when determining the potential for impacts resulting from anthropogenic sound exposure.

Social relationships

Social interactions between mammals can be affected by noise via the disruption of communication signals or by the displacement of individuals. Disruption of social relationships therefore depends on the disruption of other behaviors (e.g., caused avoidance, masking, etc.) and no specific overview is provided here. However, social disruptions must be considered in context of the relationships that are affected. Long-term disruptions of mother/calf pairs or mating displays have the potential to affect the growth and survival or reproductive effort/success of individuals, respectively.

Vocalizations

Vocal changes in response to anthropogenic noise can occur across the repertoire of sound production modes used by marine mammals, such as whistling, echolocation click production, calling, and singing. Changes may result in response to a need to compete with an increase in background noise or may reflect an increased vigilance or startle response. For example, in the presence of low-frequency active sonar, humpback whales have been observed to increase the length of their ”songs” (Miller et al. 2000, Fristrup et al. 2003), possibly due to the overlap in frequencies between the whale song and the low-frequency active sonar. A similar compensatory effect for the presence of low frequency vessel noise has been suggested for right whales; right whales have been observed to shift the frequency content of their calls upward while reducing the rate of calling in areas of increased anthropogenic noise (Parks et al. 2007). Killer whales off the northwestern coast of the United States have been observed to increase the duration of primary calls once a threshold in observing vessel density (e.g., whale watching) was reached, which has been suggested as a response to increased masking noise produced by the vessels (Foote et al. 2004). In contrast, both sperm and pilot whales potentially ceased sound production during the Heard Island feasibility test (Bowles et al. 1994), although it cannot be absolutely determined whether the inability to acoustically detect the animals was due to the cessation of sound production or the displacement of animals from the area.

Avoidance

Avoidance is the displacement of an individual from an area as a result of the presence of a sound. It is qualitatively different from the flight response in its magnitude (i.e., directed movement, rate of travel, etc.). Oftentimes avoidance is temporary, and animals return to the area once the noise has ceased. Longer term displacement is possible, however, which can lead to changes in abundance or distribution patterns of the species in the affected region if they do not become acclimated to the presence of the sound (Blackwell et al. 2004, Bejder et al. 2006, Teilmann et al. 2006). Acute avoidance responses have been observed in captive porpoises and pinnipeds exposed to a number of different sound sources (Kastelein et al. 2000, Finneran et al. 2003, Kastelein et al. 2006a, Kastelein et al. 2006b). Short term avoidance of seismic surveys, low frequency emissions, and acoustic deterrents has also been noted in wild populations of odontocetes (Bowles et al. 1994, Goold 1996, 1998, Stone et al. 2000, Morton and Symonds 2002) and to some extent in mysticetes (Gailey et al. 2007), while longer term or repetitive/chronic displacement for some dolphin groups and for manatees has been suggested to be due to the presence of chronic vessel noise (Haviland-Howell et al. 2007, Miksis-Olds et al. 2007).

Orientation

A shift in an animal's resting state or an attentional change via an orienting response represent behaviors that would be considered mild disruptions if occurring alone, and thus are placed at the bottom of the framework behavior list. As previously mentioned, the responses may co-occur with other behaviors; for instance, an animal may initially orient toward a sound source, and then move away from it. Thus, any orienting response should be considered in context of other reactions that may occur.

6.1.1.4 Life Function

Proximate Life Functions

Proximate life history functions are the functions that the animal is engaged in at the time of acoustic exposure. The disruption of these functions, and the magnitude of the disruption, is something that must be considered in determining how the ultimate life history functions are affected. Consideration of the magnitude of the effect to each of the proximate life history functions is dependent upon the life stage of the animal. For example, an animal on a breeding ground which is sexually immature will suffer relatively little consequence to disruption of breeding behavior when compared to an actively displaying adult of prime reproductive age.

Ultimate Life Functions

The ultimate life functions are those that enable an animal to contribute to the population (or stock, or species, etc.). The impact to ultimate life functions will depend on the nature and magnitude of the perturbation to proximate life history functions. Depending on the severity of the response to the stressor, acute perturbations may have nominal to profound impacts on ultimate life functions. For example, unit-level use of sonar by a vessel transiting through an area that is utilized for foraging, but not for breeding, may disrupt feeding by exposed animals for a brief period of time. Because of the brevity of the perturbation, the impact to ultimate life functions may be negligible. By contrast, weekly training over a period of years may have a more substantial impact because the stressor is chronic. Assessment of the magnitude of the stress response from the chronic perturbation would require an understanding of how and whether animals acclimate to a specific, repeated stressor and whether chronic elevations in the stress response (e.g., cortisol levels) produce fitness deficits.

The proximate life functions are loosely ordered in decreasing severity of impact. Mortality (survival) has an immediate effect, in that no future reproductive success is feasible and there is no further addition to the population resulting from reproduction. Severe injuries may also lead to reduced survivorship (longevity) and prolonged alterations in behavior. The latter may further affect an animal's overall reproductive success and reproductive effort. Disruptions of breeding have an immediate impact on reproductive effort and may impact reproductive success. The magnitude of the effect will depend on the duration of the disruption and the type of behavior change that was provoked. Disruptions to feeding and migration can affect all of the ultimate life functions; however, the impacts to reproductive effort and success are not likely to be as severe or immediate as those incurred by mortality and breeding disruptions. Taking into account these considerations, it was determined if there were population and species effects.

6.1.2 Regulatory Framework

The MMPA prohibits the unauthorized harassment of marine mammals and provides the regulatory processes for authorization for any such incidental harassment that might occur during an otherwise lawful activity.

The model for estimating potential acoustic effects from ASW training activities on cetacean species makes use of the methodology that was developed in cooperation with the National Oceanic and Atmospheric Administration (NOAA) for the Navy's Draft EIS/OEIS (DoN 2005). Via response comment letter to Undersea Warfare Training Range received from NMFS dated January 30, 2006, NMFS concurred with the use of Energy Flux Density Level (EL) for the determination of physiological effects to marine mammals. Therefore, this methodology is used to estimate the annual exposure of marine mammals that may be considered MMPA Level A harassment or MMPA Level B harassment as a result of temporary, recoverable physiological effects.

In addition, the approach for estimating potential effects from training activities on marine mammal makes use of the comments received and documents associated with previous Navy National Environmental Policy Act (NEPA) documents analyzing Navy training activities (DoN 2008). As a result of these analyses and in consultation with NMFS, this analysis uses a risk function approach to evaluate the potential for non-TTS MMPA Level B harassment from behavioral effects. The risk function is further explained in Section 6.2.

A number of Navy actions and NOAA rulings have helped to qualify possible events deemed as "harassment" under the MMPA (e.g., DoN 2008). As stated previously, "harassment" under the MMPA includes both potential injury (Level A), and disruptions of natural behavioral patterns to a point where they are abandoned or significantly altered (Level B). NMFS also includes mortality as a possible outcome to consider in addition to MMPA Level A and MMPA Level B harassment. The acoustic effects analysis and exposure calculations are based on the following premises:

Harassment that may result from Navy activities described in this LOA request is unintentional and incidental to those activities.

The acoustic effects analysis is based on primary exposures only. Secondary, or indirect, effects, such as susceptibility to predation following injury and injury resulting from disrupted behavior, while possible, can only be reliably predicted in circumstances where the responses have been well documented. Consideration of secondary effects would result in much MMPA Level A harassment being considered MMPA Level B harassment, and vice versa, since much injury (Level A harassment) has the potential to disrupt behavior (Level B harassment), and much temporary physiological or behavioral disruption (Level B) could be conjectured to have the potential for injury (Level A). Consideration of secondary effects would lead to circular definitions of harassment. However, consistent with prior ruling (NOAA 2001, 2006b), this LOA request assumes that MMPA Level A and MMPA Level B do not overlap so as to preclude circular definitions of harassment.

An individual animal predicted to experience simultaneous multiple injuries, multiple disruptions, or both, is counted as a single take (NOAA 2001, 2006b, 2009). NMFS has defined a 24-hour "refresh rate," or amount of time in which an individual can be harassed no more than once. Behavioral harassment, under the risk function presented in this request, uses received SPL over a 24-hour period as the metric for determining the probability of harassment. The Navy has determined that all proposed sonar activities would be shorter than a 24-hour period. Additional model assumptions account for ship movement, make adjustments for multiple ships and make adjustments for the presence of land shadows.

6.1.3 Integration of Regulatory and Biological Frameworks

This section presents a biological framework within which potential effects can be categorized and then related to the existing regulatory framework of injury (MMPA Level A harassment) and behavioral disruption (MMPA Level B harassment). The information presented in Sections 6.4 and 6.5 is used to develop specific numerical exposure thresholds and risk function exposure estimations. Exposure thresholds are combined with sound propagation models and species distribution data to estimate the potential exposures.

6.1.3.1 Physiological and Behavioral Effects

Sound exposure may affect multiple biological traits of a marine animal; however, the MMPA as amended directs which traits should be used when determining effects. Effects that address injury are considered Level A harassment under MMPA. Effects that address behavioral disruption are considered Level B harassment under MMPA.

The biological framework proposed here is structured according to potential physiological and behavioral effects resulting from sound exposure. The range of effects may then be assessed to determine which qualify as injury or behavioral disturbance under MMPA regulations Physiology and behavior are chosen over other biological traits because:

- They are consistent with regulatory statements defining harassment by injury and harassment by disturbance.
- They are components of other biological traits that may be relevant.
- They are a more sensitive and immediate indicator of effect.

For example, ecology is not used as the basis of the framework because the ecology of an animal is dependent on the interaction of an animal with the environment. The animal's interaction with the environment is driven both by its physiological function and its behavior, and an ecological impact may not be observable over short periods of observation. Ecological information is considered in the analysis of the effects of individual species.

A "physiological effect" is defined here as one in which the "normal" physiological function of the animal is altered in response to sound exposure. Physiological function is any of a collection of processes ranging from biochemical reactions to mechanical interaction and operation of organs and tissues within an animal. A physiological effect may range from the most significant of impacts (i.e., mortality and serious injury) to lesser effects that would define the lower end of the physiological impact range, such as the noninjurious distortion of auditory tissues. This latter physiological effect is important to the integration of the biological and regulatory frameworks and will receive additional attention in later sections.

A "behavioral effect" is one in which the "normal" behavior or patterns of behavior of an animal are overtly disrupted in response to an acoustic exposure. Examples of behaviors of concern can be derived from the harassment definitions in the MMPA.

In this LOA request the term "normal" is used to qualify distinctions between physiological and behavioral effects. Its use follows the convention of normal daily variation in physiological and behavioral function without the influence of anthropogenic acoustic sources. As a result, this LOA request uses the following definitions:

- A **physiological effect** is a variation in an animal's respiratory, endocrine, hormonal, circulatory, neurological, or reproductive activity and processes, beyond the animal's normal range of variability, in response to human activity or to an exposure to a stimulus such as active sonar.
- A **behavioral effect** is a variation in the pattern of an animal's breathing, feeding, resting, migratory, intraspecific behavior (such as reproduction, mating, territorial, rearing, and agonistic behavior), and interspecific beyond the animal's normal pattern of variability in response to human activity or to an exposure to a stimulus such as active sonar.

The definitions of physiological effect and behavioral effect used within this document should not be confused with more global definitions applied to the field of biology or to existing federal law. It is reasonable to expect some physiological effects to result in subsequent behavioral effects. For example, a marine mammal that suffers a severe injury may be expected to alter diving or foraging to the degree that its variation in these behaviors is outside that which is considered normal for the species. If a physiological effect is accompanied by a behavioral effect, the overall effect is characterized as a physiological effect; physiological effects take precedence over behavioral effects with regard to their ordering. This approach provides the most conservative ordering of effects with respect to severity, provides a rational approach to dealing with the overlap of the definitions, and avoids circular arguments.

The severity of physiological effects generally decreases with decreasing sound exposure and/or increasing distance from the sound source. The same generalization does not consistently hold for behavioral effects because they do not depend solely on the received sound level. Behavioral responses also depend on an animal's learned responses, innate response tendencies, motivational state, the pattern of the sound exposure, and the context in which the sound is presented. However, to provide a tractable approach to predicting acoustic effects that is relevant to the terms of behavioral disruption described in the MMPA, it is assumed here that the severities of behavioral effects also decrease with decreasing sound exposure and/or increasing distance from the sound source. Figure 6-2 shows the relationship between severity of effects, source distance, and exposure level, as defined in this LOA request.

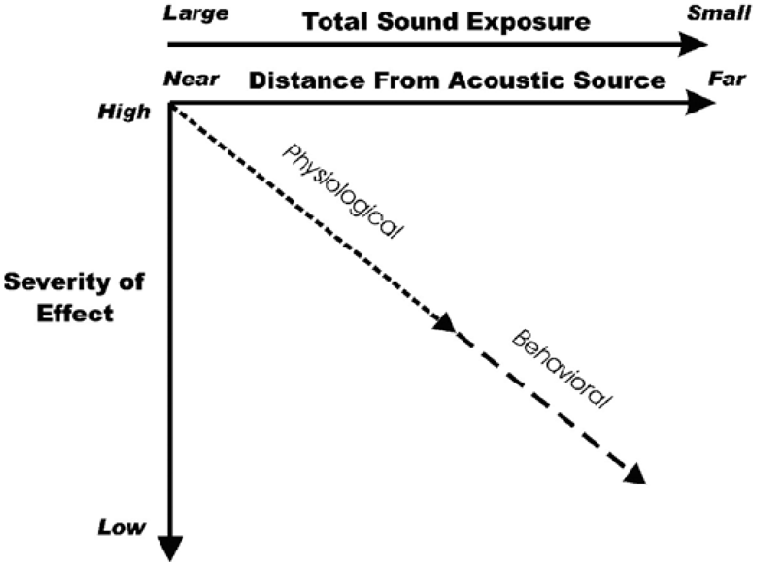


Figure 6-2. Relationship Between Severity of Effects, Source Distance, and Exposure Level

6.1.3.2 MMPA Level A Harassment and MMPA Level B Harassment

Categorizing potential effects as either physiological or behavioral effects allows them to be related to the harassment definitions. For military readiness activities, MMPA Level A harassment includes any act that injures or has the significant potential to injure a marine mammal or marine mammal stock in the wild. Injury, as defined in this LOA request and previous rulings (NOAA 2001, 2002a, 2008b, 2008c), is the destruction or loss of biological tissue from a species. The destruction or loss of biological tissue will result in an alteration of physiological function that exceeds the normal daily physiological variation of the intact tissue. For example, increased localized histamine production, edema, production of scar tissue, activation of clotting factors, white blood cell response, etc., may be expected following injury. Therefore, this LOA request assumes that all injury is qualified as a physiological effect and, to be consistent with prior actions and rulings (NOAA 2001, 2008b, 2008c), all injuries (slight to severe) are considered MMPA Level A harassment.

Public Law 108-136 (2004) amended the MMPA definitions of Level B harassment for military readiness activities, which applies to this action. For military readiness activities, MMPA Level B harassment is defined as "any act that disturbs or is likely to disturb a marine mammal or marine mammal stock by causing disruption of natural behavioral patterns including, but not limited to, migration, surfacing, nursing, breeding, feeding, or sheltering to a point where such behaviors are abandoned or significantly altered." Unlike MMPA Level A harassment, which is solely associated with physiological effects, both physiological and behavioral effects may cause MMPA Level B harassment.

For example, some physiological effects (such as TTS) can occur that are non-injurious but that can potentially disrupt the behavior of a marine mammal. These include temporary distortions in sensory tissue that alter physiological function, but that are fully recoverable without the requirement for tissue replacement or regeneration. For example, an animal that experiences a temporary reduction in hearing sensitivity suffers no injury to its auditory system, but may not perceive some sounds due to the reduction in sensitivity. As a result, the animal may not respond to sounds that would normally produce a behavioral reaction. This lack of response qualifies as a temporary disruption of normal behavioral patterns – the animal is impeded from responding in a normal manner to an acoustic stimulus.

The harassment status of slight behavior disruption has been addressed in workshops, previous actions, and rulings (NOAA 2001, 2008b, 2008c; DoN 2001a). The conclusion is that a momentary behavioral reaction of an animal to a brief, time-isolated acoustic event does not qualify as MMPA Level B harassment. A more general conclusion, that MMPA Level B harassment occurs only when there is "a potential for a significant behavioral change or response in a biologically important behavior or activity," is found in recent rulings (NOAA 2002a, 2008b, 2008c). Public Law 108-136 (2004) amended the definition of MMPA Level B harassment for military readiness activities, which applies to this action. For military readiness activities, MMPA Level B harassment is defined as "any act that disturbs or is likely to disturb a marine mammal or marine mammal stock by causing disruption of natural behavioral patterns…to a point where such behaviors are abandoned or significantly altered."

Although the temporary lack of response discussed above may not result in abandonment or significant alteration of natural behavioral patterns, the acoustic effect inputs used in the acoustic model assume that temporary hearing impairment (slight to severe) is considered MMPA Level B harassment. Although modes of action are appropriately considered, as outlined in Figure 6-3, the conservative assumption used here is to consider all hearing impairment as harassment from TTS. As a result, the actual incidental harassment of marine mammals associated with this action may be less than predicted via the analytical framework.

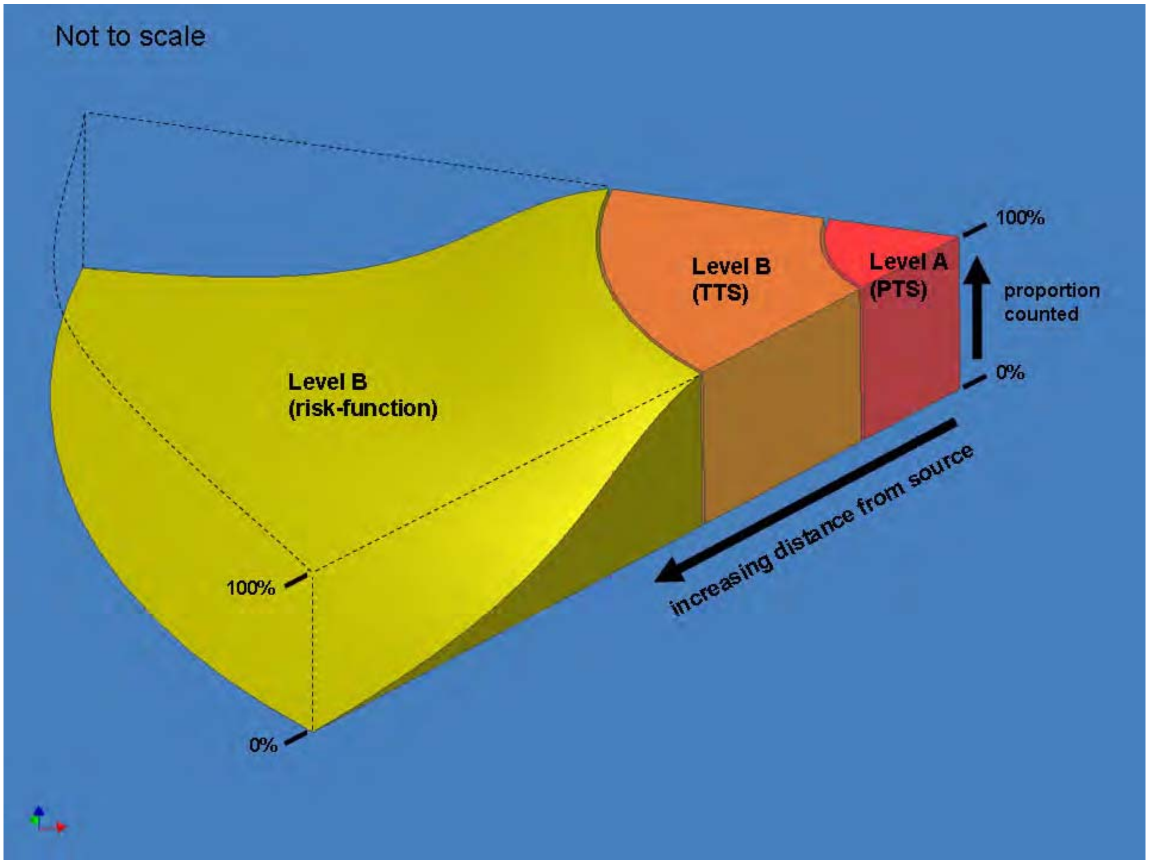


Figure 6-3. Exposure Zones Extending from a Hypothetical, Directional Sound Source

6.1.3.3 MMPA Exposure Zones

Two acoustic modeling approaches are used to account for both physiological and behavioral effects to marine mammals. When using a threshold of accumulated energy (EL) the volumes of ocean in which MMPA Level A and MMPA Level B harassment from a Threshold Shift (TS) are predicted to occur are described as exposure zones. As a conservative estimate, all marine mammals predicted to be in a zone are considered exposed to accumulated sound levels that may result in harassment within the applicable MMPA Level A (PTS) or MMPA Level B (TTS) harassment categories. MMPA non-TTS Level B (risk function) is not derived from EL, but is an estimate of the probability of non-TTS behavioral responses that NMFS would classify as harassment. See Section 6.1.5 for a thorough description of the risk function methodology. Figure 6-3 illustrates harassment zones extending from a hypothetical, directional sound source and is for illustrative purposes only and does not represent the sizes or shapes of the actual exposure zones.

As depicted in Figure 6-3, the red MMPA Level A (PTS) exposure zone extends from the source out to the distance and exposure at which the slightest amount of injury is predicted to occur (a distance of approximately 10 m [33 ft] from a SQS-53 sonar in the TMAA). The acoustic exposure that produces the slightest degree of injury is therefore the threshold value defining the outermost limit of the MMPA Level A exposure zone. Use of the threshold associated with the onset of slight injury as the most distant point and least injurious exposure takes account of all more serious injuries by inclusion within the MMPA Level A harassment zone.

The orange MMPA Level B (TTS) exposure zone begins just beyond the point of slightest injury (10 m [33 ft]) and extends outward from that point to include all animals that may possibly experience MMPA Level B harassment from TTS (a distance of approximately 178 m [584 ft] from an SQS sonar in the TMAA). Physiological effects extend beyond the range of slightest injury to a point where slight temporary distortion of the most sensitive tissue occurs, but without destruction or loss of that tissue (such as occurs with inner ear hair cells subjected to TTS). The animals predicted to be in this zone are assumed to experience MMPA Level B harassment from TTS by virtue of temporary impairment of sensory function (altered physiological function) that can disrupt behavior. The criterion and threshold used to define the outer limit of the MMPA Level B exposure zone for the on-set of certain physiological effects are given in Figure 6-3.

On the figure in the yellow non-TTS MMPA Level B harassment exposure zone, varying percentages of exposed animals would be included under MMPA Level B harassment from behavioral reactions (to a distance of approximately 105 km [57 nm] from a SQS-53 sonar in the TMAA).

6.1.3.4 Auditory Tissues as Indicators of Physiological Effects

Exposure to continuous-type sound may cause a variety of physiological effects in mammals. For example, exposure to very high sound levels may affect the function of the visual system, vestibular system, and internal organs (Ward 1997). Exposure to high-intensity, continuous type sounds of sufficient duration may cause injury to the lungs and intestines (e.g., Dalecki et al. 2002). Sudden, intense sounds may elicit a “startle” response and may be followed by an orienting reflex (Ward 1997, Jansen 1998). The primary physiological effects of sound, however, are on the auditory system (Ward 1997).

The mammalian auditory system consists of the outer ear, middle ear, inner ear, and central nervous system. Sound waves are transmitted through the middle ears to fluids within the inner ear except cetaceans. The inner ear contains delicate electromechanical hair cells that convert the fluid motions into neural impulses that are sent to the brain. The hair cells within the inner ear are the most vulnerable to over-stimulation by sound exposure (Yost 1994).

Very high sound levels may rupture the eardrum or damage the small bones in the middle ear (Yost 1994). Lower level exposures of sufficient duration may cause permanent or temporary hearing loss; such an effect is called a noise-induced threshold shift, or simply a TS (Miller 1974). A TS may be either permanent, in which case it is called a PTS, or temporary, in which case it is called a TTS. Still lower levels of sound may result in auditory masking (described in Section 3.19), which may interfere with an animal’s ability to hear other concurrent sounds.

Because the tissues of the ear appear to be the most susceptible to the physiological effects of sound and TSs tend to occur at lower exposures than other more serious auditory effects, PTS and TTS are used here as the biological indicators of physiological effects. TTS is the first indication of physiological noninjurious change and is not physical injury. The remainder of this section is, therefore, focused on TSs, including PTSs and TTSs. Since masking (without a resulting TS) is not associated with abnormal physiological function, it is not considered a physiological effect in this LOA request, but rather a potential behavioral effect. Descriptions of other potential physiological effects, including acoustically mediated bubble growth and air cavity resonance, are described in the Section 6.3.2.

6.1.3.5 Noise-Induced Threshold Shifts

The amount of TS depends on the amplitude, duration, frequency, and temporal pattern of the sound exposure. Threshold shifts will generally increase with the amplitude and duration of sound exposure. For continuous sounds, exposures of equal energy will lead to approximately equal effects (Ward 1997). For intermittent sounds, less TS will occur than from a continuous exposure with the same energy (some recovery will occur between exposures) (Kryter et al. 1966, Ward 1997).

The magnitude of a TS normally decreases with the amount of time post-exposure (Miller 1974). The amount of TS just after exposure is called the initial TS. If the TS eventually returns to zero (the threshold returns to the pre-exposure value), the TS is a TTS. Since the amount of TTS depends on the time post-exposure, it is common to use a subscript to indicate the time in minutes after exposure (Quaranta et al. 1998). For example, TTS_2 means a TTS measured two minutes after exposure. If the TS does not return to zero but leaves some finite amount of TS, then that remaining TS is a PTS. The distinction between PTS and TTS is based on whether there is a complete recovery of a TS following a sound exposure. Figure 6-4 shows two hypothetical TSs: one that completely recovers, a TTS, and one that does not completely recover, leaving some PTS.

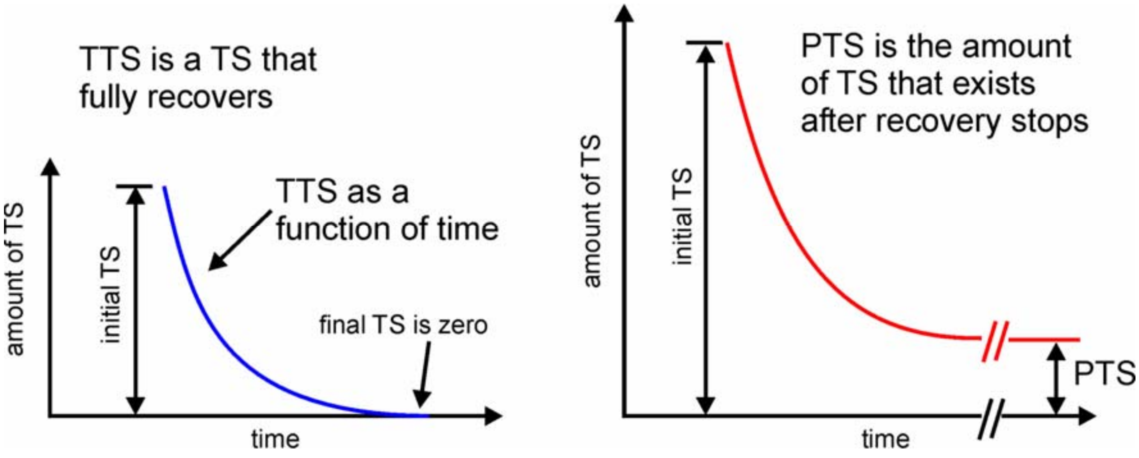


Figure 6-4. Hypothetical Temporary and Permanent Threshold Shifts

6.1.3.6 PTS, TTS, and Exposure Zones

PTS is non-recoverable and, by definition, must result from the destruction of tissues within the auditory system. PTS therefore qualifies as an injury and is classified as Level A harassment under the wording of the MMPA. In the TMAA, the smallest amount of PTS (onset- PTS) is taken to be the indicator for the smallest degree of injury that can be measured. The acoustic exposure associated with onset-PTS is used to define the outer limit of the MMPA Level A exposure zone.

TTS is recoverable and, as in recent rulings (NOAA 2001, 2002a, 2009), is considered to result from the temporary, non-injurious distortion of hearing-related tissues. In the TMAA, the smallest measurable amount of TTS (onset-TTS) is taken as the best indicator for slight temporary sensory impairment. Because it is considered non-injurious, the acoustic exposure associated with onset-TTS is used to define the outer limit of the portion of the MMPA Level B exposure zone attributable to physiological effects. This follows from the concept that hearing loss potentially affects an animal's ability to react normally to the sounds around it. Therefore, in the TMAA, the potential for TTS is considered as a MMPA Level B harassment that is mediated by physiological effects on the auditory system.

6.1.4 Criteria and Thresholds for Physiological Effects (Sensory Impairment)

This section presents the effect criteria and thresholds for physiological effects of sound leading to injury and behavioral disturbance as a result of sensory impairment. Tissues of the ear are the most susceptible to physiological effects of underwater sound. PTS and TTS were determined to be the most appropriate biological indicators of physiological effects that equate to the onset of injury (Level A harassment) and behavioral disturbance (Level B harassment from TTS), respectively. This section is, therefore, focused on criteria and thresholds to predict PTS and TTS in marine mammals.

Marine mammal ears are functionally and structurally similar to terrestrial mammal ears; however, there are important differences (Ketten 1998). The most appropriate information from which to develop PTS/TTS criteria for marine mammals would be experimental measurements of PTS and TTS from marine mammal species of interest. TTS data exist for several marine mammal species and may be used to develop meaningful TTS criteria and thresholds. Because of the ethical issues presented, PTS data do not exist for marine mammals and are unlikely to be obtained. Therefore, PTS criteria must be extrapolated using TTS criteria and estimates of the relationship between TTS and PTS.

This section begins with a review of the existing marine mammal TTS data. The review is followed by a discussion of the relationship between TTS and PTS. The specific criteria and thresholds for TTS and PTS used in this LOA request are then presented. This is followed by discussions of sound energy flux density level (EL), the relationship between EL and sound pressure level (SPL), and the use of SPL and EL in previous environmental compliance documents.

6.1.4.1 EL and SPL

EL is measure of the sound energy flow per unit area expressed in decibels (dB). EL is stated in dB referenced to 1 micropascal squared per second (dB re 1 μPa^2-s) for underwater sound and dB re (20 $\mu Pa)^2$-s for airborne sound.

SPL is a measure of the root-mean square (rms), or “effective,” sound pressure in decibels. SPL is expressed in dB re 1 µPa for underwater sound and dB re 20 µPa for airborne sound.

6.1.4.2 TTS in Marine Mammals

A number of investigators have measured TTS in marine mammals. These studies measured hearing thresholds in trained marine mammals before and after exposure to intense sounds. Some of the more important data obtained from these studies are onset-TTS levels – exposure levels sufficient to cause a just-measurable amount of TTS, often defined as 6 dB of TTS (for example, Schlundt et al. 2000). The existing cetacean and pinniped underwater TTS data are summarized in the following bullets.

- Schlundt et al. (2000) reported the results of TTS experiments conducted with bottlenose dolphins and white whales exposed to 1-second tones. This paper also includes a reanalysis of preliminary TTS data released in a technical report by Ridgway et al. (1997). At frequencies of 3, 10, and 20 kilohertz (kHz), SPLs necessary to induce measurable amounts (6 dB or more) of TTS were between 192 and 201 dB re 1 µPa (EL = 192 to 201 dB re 1 μPa^2-s). The mean exposure SPL and EL for onset-TTS were 195 dB re 1 µPa and 195 dB re 1 μPa^2-s, respectively. The sound exposure stimuli (tones) and relatively large number of test subjects (five dolphins and two white whales) make the Schlundt et al. (2000) data the most directly relevant TTS information for the scenarios described in this LOA request.

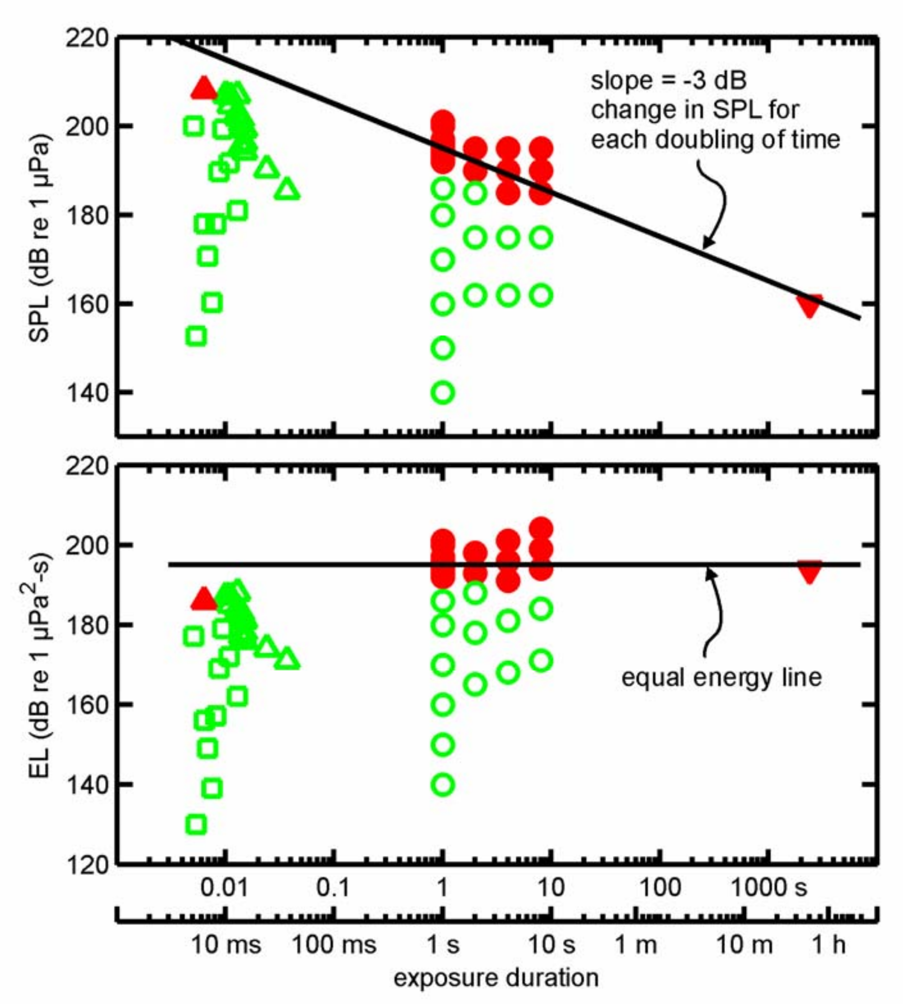
- Finneran et al. (2001, 2003, 2005) described TTS experiments conducted with bottlenose dolphins exposed to 3-kHz tones with durations of 1, 2, 4, and 8 seconds. Small amounts of TTS (3 to 6 dB) were observed in one dolphin after exposure to ELs between 190 and 204 dB re 1 μPa^2-s. These results were consistent with the data of Schlundt et al. (2000) and showed that the Schlundt et al. (2000) data were not significantly affected by the masking sound used. These results also confirmed that, for tones with different durations, the amount of TTS is best correlated with the exposure EL rather than the exposure SPL.

- Finneran et al. (2007) conducted TTS experiments with bottlenose dolphins exposed to intense 20 kHz fatiquing tone. Behavioral and auditory evoked potentials (using sinusoidal amplitude modulated tones creating auditory steady state response [AASR]) were used to measure TTS. The fatiguing tone was either 16 (mean = 193 re 1µPa, SD = 0.8) or 64 seconds (185-186 re 1µPa) in duration. TTS ranged from 19-33db from behavioral measurements and 40-45dB from ASSR measurements.
- Nachtigall et al. (2003) measured TTS in a bottlenose dolphin exposed to octave-band sound centered at 7.5 kHz. Nachtigall et al. (2003a) reported TTSs of about 11 dB measured 10 to 15 min after exposure to 30 to 50 min of sound with SPL 179 dB re 1 µPa (EL about 213 dB re µPa^2-s). No TTS was observed after exposure to the same sound at 165 and 171 dB re 1 µPa. Nachtigall et al. (2003b) reported TTSs of around 4 to 8 dB 5 min after exposure to 30 to 50 min of sound with SPL 160 dB re 1 µPa (EL about 193 to 195 dB re 1 µPa^2-s). The difference in results was attributed to faster post-exposure threshold measurement—TTS may have recovered before being detected by Nachtigall et al. (2003a). These studies showed that, for long-duration exposures, lower sound pressures are required to induce TTS than are required for short-duration tones. These data also confirmed that, for the cetaceans studied, EL is the most appropriate predictor for onset-TTS.
- Finneran et al. (2000, 2002) conducted TTS experiments with dolphins and white whales exposed to impulsive sounds similar to those produced by distant at-sea explosions and seismic water guns. These studies showed that, for very short-duration impulsive sounds, higher sound pressures were required to induce TTS than for longer-duration tones.
- Kastak et al. (1999, 2005) conducted TTS experiments with three species of pinnipeds, California sea lion, northern elephant seal and a Pacific harbor seal, exposed to continuous underwater sounds at levels of 80 and 95 dB Sensation Level (referenced to the animal's absolute auditory threshold at the center frequency) at 2.5 and 3.5 kHz for up to 50 min. Mean TTS shifts of up to 12.2 dB occurred with the harbor seals showing the largest shift of 28.1 dB. Increasing the sound duration had a greater effect on TTS than increasing the sound level from 80 to 95 dB.

Figure 6-5 shows the existing TTS data for cetaceans (dolphins and white whales). Individual exposures are shown in terms of SPL versus exposure duration (upper panel) and EL versus exposure duration (lower panel). Exposures that produced TTS are shown as filled symbols. Exposures that did not produce TTS are represented by open symbols. The squares and triangles represent impulsive test results from Finneran et al. 2000 and 2002, respectively. The circles show the 3-, 10-, and 20-kHz data from Schlundt et al. (2000) and the results of Finneran et al. (2003). The inverted triangle represents data from Nachtigall et al. (2003b).

Figure 6-5 illustrates that the effects of the different sound exposures depend on the SPL and duration. As the duration decreases, higher SPLs are required to cause TTS. In contrast, the ELs required for TTS do not show the same type of variation with exposure duration. At this time the raw data for pinnipeds is not available to construct a similar graph of TTS in pinnipeds as there is for cetaceans in Figure 6-5.

The solid line in the upper panel of Figure 6-5 has a slope of -3 dB per doubling of time. This line passes through the point where the SPL is 195 dB re 1 µPa and the exposure duration is 1 second. Since EL = SPL + 10log10 (duration), doubling the duration increases the EL by 3 dB. Subtracting 3 dB from the SPL decreases the EL by 3 dB. The line with a slope of -3 dB per doubling of time, therefore, represents an equal energy line – all points on the line have the same EL, which is, in this case, 195 dB re 1 µPa^2-s. This line appears in the lower panel as a horizontal line at 195 dB re 1 µPa^2-s. The equal energy line at 195 dB re 1 µPa^2-s fits the tonal and sound data (the nonimpulsive data) very well, despite differences in exposure duration, SPL, experimental methods, and subjects.



Legend: Filled symbol: Exposure that produced TTS, Open symbol: Exposure that did not produce TTS Squares: Impulsive test results from Finneran et al. 2000, Triangles: Impulsive test results from Finneran et al. 2002, Circles: 3, 10, and 20-kHz data from Schlundt et al. (2000) and results of Finneran et al. (2003), and Inverted triangle: Data from Nachtigall et al. 2004.

Figure 6-5. Existing TTS Data for Cetaceans

In summary, the existing cetacean TTS data show that, for the species studied and sounds (nonimpulsive) of interest, the following is true:

- The growth and recovery of TTS are analogous to those in land mammals. This means that, as in land mammals, cetacean TSs depend on the amplitude, duration, frequency content, and temporal pattern of the sound exposure. Threshold shifts will generally increase with the amplitude and duration of sound exposure. For continuous sounds, exposures of equal energy will lead to approximately equal effects (Ward 1997). For intermittent sounds, less TS will occur than from a continuous exposure with the same energy (some recovery will occur between exposures) (Kryter et al. 1966, Ward 1997).
- SPL by itself is not a good predictor of onset-TTS, since the amount of TTS depends on both SPL and duration.

- Exposure EL is correlated with the amount of TTS and is a good predictor for onset-TTS for single, continuous exposures with different durations. This agrees with human TTS data presented by Ward et al. (1958, 1959).
- An energy flux density level of 195 dB re 1 μPa^2-s is the most appropriate predictor for onset-TTS from a single, continuous exposure.
- For the purposes of this Draft EIS/OEIS a measurable amount of 6 dB is considered the onset of TTS.

6.1.4.3 Relationship between TTS and PTS

Since marine mammal PTS data do not exist, onset-PTS levels for these animals must be estimated using TTS data and relationships between TTS and PTS. Much of the early human TTS work was directed towards relating TTS_2 after 8 hours of sound exposure to the amount of PTS that would exist after years of similar daily exposures (e.g., Kryter et al. 1966). Although it is now acknowledged that susceptibility to PTS cannot be reliably predicted from TTS measurements, TTS data do provide insight into the amount of TS that may be induced without a PTS. Experimental studies of the growth of TTS may also be used to relate changes in exposure level to changes in the amount of TTS induced. Onset-PTS exposure levels may therefore be predicted by:

- Estimating the largest amount of TTS that may be induced without PTS. Exposures causing a TS greater than this value are assumed to cause PTS.
- Estimating the additional exposure, above the onset-TTS exposure, necessary to reach the maximum allowable amount of TTS that, again, may be induced without PTS. This is equivalent to estimating the growth rate of TTS – how much additional TTS is produced by an increase in exposure level.

Experimentally induced TTSs, from short duration sounds 1-8 seconds in the range of 3.5-20 kHz, in marine mammals have generally been limited to around 2 to 10 dB, well below TSs that result in some PTS. Experiments with terrestrial mammals have used much larger TSs and provide more guidance on how high a TS may rise before some PTS results. Early human TTS studies reported complete recovery of TTSs as high as 50 dB after exposure to broadband sound (Ward 1960; Ward et al. 1958, 1959). Ward et al. (1959) also reported slower recovery times when TTS_2 approached and exceeded 50 dB, suggesting that 50 dB of TTS_2 may represent a "critical" TTS. Miller et al. (1963) found PTS in cats after exposures that were only slightly longer in duration than those causing 40 dB of TTS. Kryter et al. (1966) stated: "A TTS_2 that approaches or exceeds 40 dB can be taken as a signal that danger to hearing is imminent." These data indicate that TSs up to 40 to 50 dB may be induced without PTS, and that 40 dB is a reasonable upper limit for TS to prevent PTS.

The small amounts of TTS produced in marine mammal studies also limit the applicability of these data to estimates of the growth rate of TTS. Fortunately, data do exist for the growth of TTS in terrestrial mammals. For moderate exposure durations (a few min to hours), TTS_2 varies with the logarithm of exposure time (Ward et al. 1958, 1959; Quaranta et al. 1998). For shorter exposure durations the growth of TTS with exposure time appears to be less rapid (Miller 1974, Keeler 1976). For very long-duration exposures, increasing the exposure time may fail to produce any additional TTS, a condition known as asymptotic threshold shift (Saunders et al. 1977, Mills et al. 1979).

Ward et al. (1958, 1959) provided detailed information on the growth of TTS in humans. Ward et al. (1958, 1959) presented the amount of TTS measured after exposure to specific SPLs and durations of broadband sound. Since the relationship between EL, SPL, and duration is known, these same data could be presented in terms of the amount of TTS produced by exposures with different ELs.

Figure 6-6 shows results from Ward et al. (1958, 1959) plotted as the amount of TTS_2 versus the exposure EL. The data in Figure 3.8-8 (a) are from broadband (75 Hz to 10 kHz) sound exposures with durations of 12 to 102 min (Ward et al. 1958). The symbols represent mean TTS_2 for 13 individuals exposed to continuous sound. The solid line is a linear regression fit to all but the two data points at the lowest exposure EL. The experimental data are fit well by the regression line (R2 = 0.95). These data are important for two reasons: (1) they confirm that the amount of TTS is correlated with the exposure EL; and (2) the slope of the line allows one to estimate the in additional amount of TTS produced by an increase in exposure. For example, the slope of the line in Figure 6-6 is approximately 1.5 dB TTS_2 per dB of EL. This means that each additional dB of EL produces 1.5 dB of additional TTS_2.

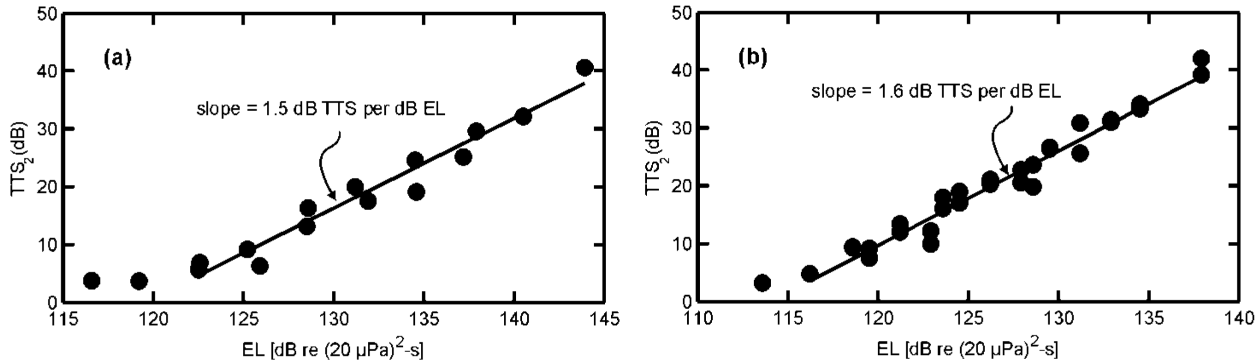


Figure 6-6. Growth of TTS versus the Exposure EL (from Ward et al. [1958, 1959])

The data in Figure 6-6 are from octave-band sound exposures (2.4 to 4.8 kHz) with durations of 12 to 102 minutes (Ward et al. 1959). The symbols represent mean TTS for 13 individuals exposed to continuous sound. The linear regression was fit to all but the two data points at the lowest exposure EL. The slope of the regression line fit to the mean TTS data was 1.6 dB TTS_2/dB EL. A similar procedure was carried out for the remaining data from Ward et al. (1959), with comparable results. Regression lines fit to the TTS versus EL data had slopes ranging from 0.76 to 1.6 dB TTS_2/dB EL, depending on the frequencies of the sound exposure and hearing test.

An estimate of 1.6 dB TTS_2 per dB increase in exposure EL is the upper range of values from Ward et al. (1958, 1959) and gives the most conservative estimate – it predicts a larger amount of TTS from the same exposure compared to the lines with smaller slopes. The difference between onset-TTS (6 dB) and the upper limit of TTS before PTS (40 dB) is 34 dB. To move from onset-TTS to onset-PTS, therefore, requires an increase in EL of 34 dB divided by 1.6 dB/dB, or approximately 21 dB. An estimate of 20 dB between exposures sufficient to cause onset-TTS and those capable of causing onset-PTS is a reasonable approximation.

To summarize:

In the absence of marine mammal PTS data, onset-PTS exposure levels may be estimated from marine mammal TTS data and PTS/TTS relationships observed in terrestrial mammals. This involves:

- Estimating the largest amount of TTS that may be induced without PTS. Exposures causing a TS greater than this value are assumed to cause PTS.
- Estimating the growth rate of TTS – how much additional TTS is produced by an increase in exposure level.

- A variety of terrestrial mammal data sources point toward 40 dB as a reasonable estimate of the largest amount of TS that may be induced without PTS. A conservative is that continuous-type exposures producing TSs of 40 dB or more always result in some amount of PTS.
- Data from Ward et al. (1958, 1959) reveal a linear relationship between TTS_2 and exposure EL. A value of 1.6 dB TTS_2 per dB increase in EL is a conservative estimate of how much additional TTS is produced by an increase in exposure level for continuous- type sounds.
- There is a 34 dB TS difference between onset-TTS (6 dB) and onset-PTS (40 dB). The additional exposure above onset-TTS that is required to reach PTS is therefore 34 dB divided by 1.6 dB/dB, or approximately 21 dB.
- Exposures with ELs 20 dB above those producing TTS may be assumed to produce a PTS. This number is used as a conservative simplification of the 21 dB number derived above.

6.1.4.4 Threshold Levels for Harassment from Physiological Effects

For this specified action, sound exposure thresholds for modeling TTS and PTS exposures are as presented in Table 6-1.

Table 6-1. Summary of the Physiological Effects Thresholds for TTS and PTS for Cetaceans and Pinnipeds

Species	Criteria	Threshold (dB re 1μPa^2-s)	MMPA Harassment
Cetaceans All species	TTS PTS	195 215	Level B Level A
Pinniped			
California Sea Lion	TTS PTS	206 226	Level B Level A
Northern Elephant Seal	TTS PTS	204 224	Level B Level A
Northern Fur Seal	TTS PTS	206 226	Level B Level A
Steller Sea Lion	TTS PTS	206 226	Level B Level A

Notes: dB re 1μPa^2-s = decibels referenced to 1 micropascal squared per second, MMPA = Marine Mammal Protection Act, PTS = Permanent Threshold Shift, TTS = Temporary Threshold Shift

Cetaceans predicted to receive a sound exposure with EL of 215 dB re 1 μPa^2-s or greater are assumed to experience PTS and are counted as MMPA Level A harassment. Cetaceans predicted to receive a sound exposure with EL greater than or equal to 195 dB re 1 μPa^2-s but less than 215 dB re 1 μPa^2-s are assumed to experience TTS and are counted as MMPA Level B harassment from TTS.

The TTS and PTS thresholds for pinnipeds vary with species. A threshold of 206 dB re 1 μPa^2-s for TTS and 226 dB re 1 μPa^2-s for PTS is used for otariids (California sea lion, Steller sea lion, and Northern fur seal). Although this criteria is based on data from studies on California sea lions (Kastak et al. 1999, 2005), all three species are morphologically related (e.g., similar body structure and anatomy), and have similar breeding and foraging behaviors. Northern elephant seals are similar to otariids and use thresholds of TTS = 204 dB re 1 μPa^2-s, PTS = 224 dB re 1 μPa^2-s. A lower threshold is used for harbor seals (TTS = 183 dB re 1 μPa^2-s, PTS = 203 dB re 1 μPa^2-s).

6.1.4.5 Derivation of Effect Thresholds

Cetacean Threshold

The TTS threshold is primarily based on the cetacean TTS data from Schlundt et al. (2000). Since these tests used short-duration tones similar to sonar pings, they are the most directly relevant data. The mean exposure EL required to produce onset-TTS in these tests was 195 dB re 1 μPa^2-s. This result is corroborated by the short-duration tone data of Finneran et al. (2001, 2003, 2005) and the long-duration sound data from Nachtigall et al. (2003a, b). Together, these data demonstrate that TTS in cetaceans 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.

The PTS threshold is 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).

Pinniped Threshold

The TTS threshold for pinnipeds is based on TTS data from Kastak et al. (1999, 2005). Although their data is from continuous noise rather than short duration tones, pinniped TTS can be extrapolated using equal energy curves. Continuous sound at a lower intensity level can produce TTS similar to short duration but higher intensity sounds such as sonar pings.

6.1.4.6 Use of EL for Physiological Effect Thresholds

Effect thresholds are expressed in terms of total received EL. Energy flux density is a measure of the flow of sound energy through an area. Marine and terrestrial mammal data show that, for continuous-type sounds of interest, TTS and PTS are more closely related to the energy in the sound exposure than to the exposure SPL.

The EL for each individual ping is calculated from the following equation:

$$EL = SPL + 10\log_{10}(\text{duration})$$

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 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 – intermittent exposures are considered comparable to 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.

6.1.4.7 Previous Use of EL for Physiological Effects

Originally for effects criteria from at-sea (underwater) explosions, energy measures were part of dual criteria for cetacean auditory effects in ship shock trials, which only involve impulsive-type sounds (DoN 1997, 2001a). These previous actions used 192 dB re 1 µPa^2-s as a reference point to derive a TTS threshold in terms of EL. A second TTS threshold, based on peak pressure, was also used. If either threshold was exceeded, effect was assumed.

The 192 dB re 1 µPa^2-s reference point differs from the threshold of 195 dB re 1 µPa^2-s used in this LOA request. The 192 dB re 1 µPa^2-s value was based on the minimum observed by Ridgway et al. (1997) and Schlundt et al. (2000) during TTS measurements with bottlenose dolphins exposed to 1-second tones. At the time, no impulsive test data for marine mammals were available and the 1-second tonal data were considered to be the best available. The minimum value of the observed range of 192 to 201 dB re 1 µPa^2-s was used to protect against misinterpretation of the sparse data set available. The 192 dB re 1 µPa^2-s value was reduced to 182 dB re 1 µPa^2-s to accommodate the potential effects of pressure peaks in impulsive waveforms.

The additional data now available for onset-TTS in small cetaceans confirm the original range of values and increase confidence in it (Finneran et al. 2001, 2003; Nachtigall et al. 2003a, 2003b). This request for the LOA therefore, uses the more complete data available and the mean value of the entire Schlundt et al. (2000) data set (195 dB re 1 µPa^2-s), instead of the minimum of 192 dB re 1 µPa^2-s. Use of the data in this manner has been established as standard by NMFS for these types of actions in other Navy training locations in the Pacific (NOAA 2009). From the standpoint of statistical sampling and prediction theory, the mean is the most appropriate predictor—the "best unbiased estimator"—of the EL at which onset-TTS should occur; predicting the number of exposures in future actions relies (in part) on using the EL at which onset-TTS will most likely occur. When that EL is applied over many pings in each of many sonar exercises, that value will provide the most accurate prediction of the actual number of exposures by onset-TTS over all of those exercises. Use of the minimum value would overestimate the number of exposures because many animals counted would not have experienced onset-TTS. Further, there is no logical limiting minimum value of the distribution that would be obtained from continued successive testing. Continued testing and use of the minimum would produce more and more erroneous estimates.

6.1.5 Criteria and Thresholds for Level B Harassment from Non-TTS

This Section presents the effect criterion and threshold for non-TTS behavioral effects of sound leading to behavioral disturbance without accompanying physiological effects as has been established by NMFS (NOAA 2009). Since TTS is used as the biological indicator for a physiological effect leading to behavioral disturbance, the non-TTS behavioral effects discussed in this section may be thought of as behavioral disturbance occurring at exposure levels below those causing TTS.

A large body of research on terrestrial animal and human response to airborne sound exists, but results from those studies are not readily extendible to the development of effect criteria and thresholds for marine mammals. For example, "annoyance" is one of several criteria used to define impact to humans from exposure to industrial sound sources. Comparable criteria cannot be developed for marine mammals because there is no acceptable method for determining whether a nonverbal animal is annoyed. Further, differences in hearing thresholds, dynamic range of the ear, and the typical exposure patterns of interest (e.g., human data tend to focus on 8-hour-long exposures) make extrapolation of human sound exposure standards inappropriate.

Behavioral observations of marine mammals exposed to anthropogenic sound sources exist; however, there are few observations and no controlled measurements of behavioral disruption of cetaceans caused by sound sources with frequencies, waveforms, durations, and repetition rates comparable to those employed by the tactical sonars to be used in the TMAA. At the present time there is no consensus on how to account for behavioral effects on marine mammals exposed to continuous-type sounds (NRC, 2003).

6.2 Assessing MMPA Level B Non-TTS Behavioral Harassment Using Risk Function

6.2.1 Background

Based on available evidence, marine animals are likely to exhibit any of a suite of potential behavioral responses or combinations of behavioral responses upon exposure to sonar transmissions. Potential behavioral responses include, but are not limited to: avoiding exposure or continued exposure; behavioral disturbance (including distress or disruption of social or foraging activity); habituation to the sound; becoming sensitized to the sound; or not responding to the sound.

Existing studies of behavioral effects of human-made sounds in marine environments remain inconclusive, partly because many of those studies have lacked adequate controls, applied only to certain kinds of exposures (which are often different from the exposures being analyzed in the study), and had limited ability to detect behavioral changes that may be significant to the biology of the animals that were being observed. These studies are further complicated by the wide variety of behavioral responses marine mammals exhibit and the fact that those responses can vary significantly by species, individual, and the context of an exposure. In some circumstances, some individuals will continue normal behavioral activities in the presence of high levels of human-made noise. In other circumstances, the same individual or other individuals may avoid an acoustic source at much lower received levels (Richardson et al. 1995, Wartzok et al. 2003). These differences within and between individuals appear to result from a complex interaction of experience, motivation, and learning that are difficult to quantify and predict.

It is possible that some marine mammal behavioral reactions to anthropogenic sound may result in strandings. As detailed in Appendix A, several "mass stranding" events—strandings that involve two or more individuals of the same species (excluding a single cow–calf pair)—that have occurred over the past two decades have been associated with naval training activities, seismic surveys, and other anthropogenic activities that introduced sound into the marine environment. Based on the results of recent experiments with tagged beaked whales, it has been suggested that that beaked whales may be "particularly sensitive to anthropogenic sounds, but there is no evidence that they have a special sensitivity to sonar compared with other signals" (Tyack 2009). Sonar exposure has, however, been identified as a contributing cause or factor in five specific mass stranding events: Greece in 1996; the Bahamas in March 2000; Madeira, Portugal in 2000; the Canary Islands in 2002, and Spain in 2006 (Advisory Committee on Acoustic Impacts on Marine Mammals 2006).

In these five events, exposure to acoustic energy has been considered a potential indirect cause of the death of marine mammals (Cox et al. 2006). A popular hypothesis regarding a potential cause of the strandings is that tissue damage results from a "gas and fat embolic syndrome" (Fernandez et al. 2005; Jepson et al. 2003, 2005). Models of nitrogen saturation in diving marine mammals have been used to suggest that altered dive behavior might result in the accumulation of nitrogen gas such that the potential for nitrogen bubble formation is increased (Houser et al. 2001, Zimmer and Tyack 2007). If so, this mechanism might explain the findings of gas and bubble emboli in stranded beaked whales. It is also possible that stranding is a behavioral response to a sound under certain contextual conditions and that the subsequently observed physiological effects of the strandings (e.g., overheating, decomposition, or internal hemorrhaging from being on shore) were the result of the stranding and not the direct result of exposure to sonar (Cox et al. 2006).

6.2.2 Non-TTS Risk Function Adapted from Feller (1968)

To assess the potential effects on marine mammals associated with active sonar used during training activity, the Navy and NMFS as cooperating agencies in previous analysis (NOAA 2008b, 2008c) applied a risk function that estimates 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 sonar. The mathematical function is derived from a solution in Feller (1968) as defined in the SURTASS LFA Sonar Final OEIS/EIS (DoN 2001), and relied on in the Supplemental SURTASS LFA Sonar EIS (DoN 2007a) for the probability of MFA sonar risk for MMPA Level B non-TTS behavioral harassment with input parameters modified by NMFS for MFA sonar for mysticetes, odontocetes (except harbor porpoises), and pinnipeds (NMFS 2008, NOAA 2009). The same risk function and input parameters will be applied to high frequency active (HFA) (>10 kHz) sources until applicable data becomes available for high frequency sources.

In order to represent a probability of risk, the function should 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 DoN (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 for odontocetes, 8 for mysticetes).

In order to use this function, the values of the three parameters (B, K, and A) need to be established. The values used in this LOA request analysis are based on three sources of data: TTS experiments conducted at Sea Surface Control (SSC) and documented in Finneran, et al. (2001, 2003, and 2005; Finneran and Schlundt 2004); reconstruction of sound fields produced by the USS SHOUP associated with the behavioral responses of killer whales observed in Haro Strait and documented in Department of Commerce, NMFS (2005), DoN (2004), and Fromm (2004a, 2004b); and observations of the behavioral response of North Atlantic right whales exposed to alert stimuli containing mid-frequency components documented in Nowacek et al. (2004). The input parameters, as defined by NMFS, are based on very limited data that represent the best available science at this time.

6.2.2.1 Data Sources Used for Risk Function

There is widespread consensus that cetacean response to MFA sound signals needs to be better defined using controlled experiments. Navy is contributing to an ongoing behavioral response study in the Bahamas that has provided some initial information on beaked whales, the species identified as potentially the most sensitive to MFA sonar. NMFS is leading this international effort with scientists from various academic institutions and research organizations to conduct studies on how marine mammals respond to underwater sound exposures. Field experiments in 2007 and 2008 with tagged beaked whales found reactions to all introduced sound stimulus consisted of the animals stopping their clicking, producing fewer foraging buzzes than normal, and ending their dive in a long and an unusually slow ascent moving away from the sound source (Tyack 2009). This suggested that beaked whales may be "particularly sensitive to anthropogenic sounds, but there is no evidence that they have a special sensitivity to sonar compared with other signals" (Tyack 2009). These initial findings are not in conflict with the current risk function. Until additional data beyond the three recently completed experimental exposures are available, NMFS and the Navy will continue use of the risk function established for recent Final Rules under MMPA for Navy training activities (e.g., NOAA 2009). NMFS and the Navy have determined that the following three data sets remain the most applicable for the direct use in developing risk function parameters for MFA/HFA sonar. These data sets represent the only known data that specifically relate altered behavioral responses to exposure to MFA sound sources.

Data from SSC's Controlled Experiments

Most of the observations of the behavioral responses of toothed whales resulted from a series of controlled experiments on bottlenose dolphins and beluga whales conducted by researchers at SSC's facility in San Diego, California (Finneran et al. 2001, 2003, 2005; Finneran and Schlundt 2004; Schlundt et al. 2000). In experimental trials with marine mammals trained to perform tasks when prompted, scientists evaluated whether the marine mammals performed these tasks when exposed to mid-frequency tones. Altered behavior during experimental trials usually involved refusal of animals to return to the site of the sound stimulus. This refusal included what appeared to be deliberate attempts to avoid a sound exposure or to avoid the location of the exposure site during subsequent tests. (Schlundt et al. 2000, Finneran et al. 2002) Bottlenose dolphins exposed to 1-sec intense tones exhibited short-term changes in behavior above received sound levels of 178 to 193 dB re 1 micropascal (μPa) root mean square (rms), and beluga whales did so at received levels of 180 to 196 dB and above. Test animals sometimes vocalized after an exposure to impulsive sound from a seismic watergun (Finneran et al. 2002). In some instances, animals exhibited aggressive behavior toward the test apparatus (Ridgway et al. 1997, Schlundt et al. 2000).

Finneran and Schlundt (2004) examined behavioral observations recorded by the trainers or test coordinators during the Schlundt et al. (2000) and Finneran et al. (2001, 2003, 2005) experiments featuring 1-second (sec) tones. These included observations from 193 exposure sessions (fatiguing stimulus level > 141 dB re 1μPa) conducted by Schlundt et al. (2000) and 21 exposure sessions conducted by Finneran et al. (2001, 2003, 2005). The observations were made during exposures to sound sources at 0.4 kHz, 3 kHz, 10 kHz, 20 kHz, and 75 kHz. The TTS experiments that supported Finneran and Schlundt (2004) are further explained below:

Schlundt et al. (2000) provided a detailed summary of the behavioral responses of trained marine mammals during TTS tests conducted at SSC San Diego with 1-sec tones. Schlundt et al. (2000) reported eight individual TTS experiments. Fatiguing stimuli durations were 1-sec; exposure frequencies were 0.4 kHz, 3 kHz, 10 kHz, 20 kHz and 75 kHz. The experiments were conducted in San Diego Bay. Because of the variable ambient noise in the bay, low-level broadband masking noise was used to keep hearing thresholds consistent despite fluctuations in the ambient noise. Schlundt et al. (2000) reported that "behavioral alterations," or deviations from the behaviors the animals being tested had been trained to exhibit, occurred as the animals were exposed to increasing fatiguing stimulus levels.

Finneran et al. (2001, 2003, 2005) conducted TTS experiments using tones at 3 kHz. The test method was similar to that of Schlundt et al. (2000) except the tests were conducted in a pool with very low ambient noise level (below 50 dB re 1 μPa/Hz), and no masking noise was used. Two separate experiments were conducted using 1-sec tones. In the first, fatiguing sound levels were increased from 160 to 201 dB SPL. In the second experiment, fatiguing sound levels between 180 and 200 dB re 1 μPa were randomly presented.

Data from Studies of Baleen (Mysticetes) Whale Responses

The only mysticete data available resulted from a field experiments in which baleen whales (mysticetes) were exposed to a range frequency sound sources from 120 Hz to 4500 Hz (Nowacek et al. 2004). An alert stimulus, with a mid-frequency component, was the only portion of the study used to support the risk function input parameters.

Nowacek et al. (2004) documented observations of the behavioral response of North Atlantic right whales exposed to alert stimuli containing mid-frequency components. To assess risk factors involved in ship strikes, a multi-sensor acoustic tag was used to measure the responses of whales to passing ships and experimentally tested their responses to controlled sound exposures, which included recordings of ship noise, the social sounds of conspecifics and a signal designed to alert the whales. The alert signal was 18-min of exposure consisting of three 2-minute signals played sequentially three times over. The three signals had a 60 percent duty cycle and consisted of: (1) alternating 1-sec pure tones at 500 Hz and 850 Hz; (2) a 2-sec logarithmic down-sweep from 4,500 Hz to 500 Hz; and (3) a pair of low (1,500 Hz)-high (2,000 Hz) sine wave tones amplitude modulated at 120 Hz and each 1-sec long. The purposes of the alert signal were (a) to provoke an action from the whales via the auditory system with disharmonic signals that cover the whales estimated hearing range; (b) to maximize the signal to noise ratio (obtain the largest difference between background noise) and c) to provide localization cues for the whale. Five out of six whales reacted to the signal designed to elicit such behavior. Maximum received levels ranged from 133 to 148 dB re 1μPa.

Observations of Killer Whales in Haro Strait in the Wild

In May 2003, killer whales (*Orcinus orca*) were observed exhibiting behavioral responses while the USS SHOUP was engaged in MFA sonar activities in the Haro Strait in the vicinity of Puget Sound, Washington. Although these observations were made in an uncontrolled environment, the sound field that may have been associated with the sonar activities had to be estimated, and the behavioral observations were reported for groups of whales, not individual whales, the observations associated with the USS SHOUP provide the only data set available of the behavioral responses of wild, noncaptive animal upon exposure to the SQS-53 MFA sonar. U.S. Department of Commerce (NMFS 2005), DoN (2004), Fromm (2004a, 2004b) documented reconstruction of sound fields produced by the USS SHOUP associated with the behavioral response of killer whales observed in Haro Strait. Observations from this reconstruction included an approximate closest approach time which was correlated to a reconstructed estimate of received level at an approximate whale location (which ranged from 150 to 180 dB), with a mean value of 169.3 dB.

6.2.2.2 Limitations of the Risk Function Data Sources

There are significant limitations and challenges to any risk function derived to estimate the probability of marine mammal behavioral responses; these are largely attributable to sparse data. Ultimately there should be multiple functions for different marine mammal taxonomic groups, but the current data are insufficient to support them. The goal is unquestionably that risk functions be based on empirical measurement.

The risk function presented here is based on three data sets that NMFS and Navy have determined are the best available science at this time. The Navy and NMFS acknowledge each of these data sets has limitations. However, this risk function, if informed by the limited available data relevant to the MFA sonar application, has the advantages of simplicity and the fact that there is precedent for its application and foundation in marine mammal research.

While NMFS considers all data sets as being weighted equally in the development of the risk function, the Navy believes the SSC San Diego data is the most rigorous and applicable for the following reasons:

- The data represents the only source of information where the researchers had complete control over and ability to quantify the noise exposure conditions.
- The altered behaviors were identifiable due to long term observations of the animals.
- The fatiguing noise consisted of tonal exposures with limited frequencies contained in the MFA sonar bandwidth.

However, the Navy and NMFS do agree that the following are limitations associated with the three data sets used as the basis of the risk function:

- The three data sets represent the responses of only four species: trained bottlenose dolphins and beluga whales, North Atlantic right whales in the wild and killer whales in the wild.
- None of the three data sets represent experiments designed for behavioral observations of animals exposed to MFA sonar.
- The behavioral responses of marine mammals that were observed in the wild (observations of killer whales in Haro Strait) are based on an estimated received level of sound exposure; they do not take into consideration (due to minimal or no supporting data):
    - Potential relationships between acoustic exposures and specific behavioral activities (e.g., feeding, reproduction, changes in diving behavior, etc.), variables such as bathymetry, or acoustic waveguides; or

    - Differences in individuals, populations, or species, or the prior experiences, reproductive state, hearing sensitivity, or age of the marine mammal.

SSC San Diego Trained Bottlenose Dolphins and Beluga Data Set

- The animals were trained animals in captivity; therefore, they may be more or less sensitive than cetaceans found in the wild (Domjan 1998).
- The tests were designed to measure TTS, not behavior.
- Because the tests were designed to measure TTS, the animals were exposed to much higher levels of sound than the baseline risk function (only two of the total 193 observations were at levels below 160 dB re 1 μPa^2-s).

- The animals were not exposed in the open ocean but in a shallow bay or pool.

North Atlantic Right Whales in the Wild Data Set

- The observations of behavioral response were from exposure to alert stimuli that contained mid-frequency components but was not similar to a MFA sonar ping. The alert signal was 18 min of exposure consisting of three 2-min signals played sequentially three times over. The three signals had a 60 percent duty cycle and consisted of (1) alternating 1-sec pure tones at 500 Hz and 850 Hz; (2) a 2-sec logarithmic down-sweep from 4,500 Hz to 500 Hz; and (3) a pair of low (1,500 Hz)- high (2,000 Hz) sine wave tones amplitude modulated at 120 Hz and each 1-sec long. This 18-min alert stimuli is in contrast to the average 1-sec ping every 30 sec in a comparatively very narrow frequency band used by military sonar.
- The purpose of the alert signal was, in part, to provoke an action from the whales through an auditory stimulus.

Killer Whales in the Wild Data Set

- The observations of behavioral harassment were complicated by the fact that there were other sources of harassment in the vicinity (other vessels and their interaction with the animals during the observation).
- The observations were anecdotal and inconsistent. There were no controls during the observation period, with no way to assess the relative magnitude of the any observed response as opposed to baseline conditions.

6.2.2.3 Input Parameters for the Risk Function

The values of B, K, and A need to be specified in order to utilize the risk function defined in Section 6.2.2. The risk continuum function approximates the dose-response function in a manner analogous to pharmacological risk assessment. In this case, the risk function is combined with the distribution of sound exposure levels to estimate aggregate impact on an exposed population.

Basement Value for Risk—The B Parameter

The B parameter defines the basement value for risk, below which the risk is so low that calculations are impractical. This 120 dB level is taken as the estimate received level (RL) below which the risk of significant change in a biologically important behavior approaches zero for the MFA/HFA sonar risk assessment. This level is based on a broad overview of the levels at which multiple species have been reported responding to a variety of sound sources, both mid-frequency and other, was recommended by the NMFS, and has been used in other publications (DoN 2008, NOAA 2009). The Navy recognizes that for actual risk of changes in behavior to be zero, the signal-to-noise ratio of the animal must also be zero. However, the present convention of ending the risk calculation at 120 dB for MFA/HFA sonar has a negligible impact on the subsequent calculations, because the risk function does not attain appreciable values at received levels that low.

The K Parameter

NMFS and the Navy used the mean of the following values to define the midpoint of the function: (1) the mean of the lowest received levels (185.3 dB) at which individuals responded with altered behavior to 3 kHz tones in the SSC data set; (2) the estimated mean received level value of 169.3 dB produced by the reconstruction of the USS SHOUP incident in which killer whales exposed to MFA sonar (range modeled possible received levels: 150 to 180 dB); and (3) the mean of the five maximum received levels at which Nowacek et al. (2004) observed significantly altered responses of right whales to the alert stimuli than to the control (no input signal) is 139.2 dB SPL. The arithmetic mean of these three mean values is 165 dB SPL. The value of K is the difference between the value of B (120 dB SPL) and the 50 percent value of 165 dB SPL; therefore, K=45.

Risk Transition—The A Parameter

The A parameter controls how rapidly risk transitions from low to high values with increasing receive level. As A increases, the slope of the risk function increases. For very large values of A, the risk function can approximate a threshold response or step function. In consultation for the Hawaii Range Complex (HRC) EIS/OEIS, NMFS recommended that the Navy use A=10 as the value for odontocetes (except harbor porpoises), and pinnipeds, and A=8 for mysticetes (Figures 6-7 and 6-8) (NMFS 2008, NOAA 2009)

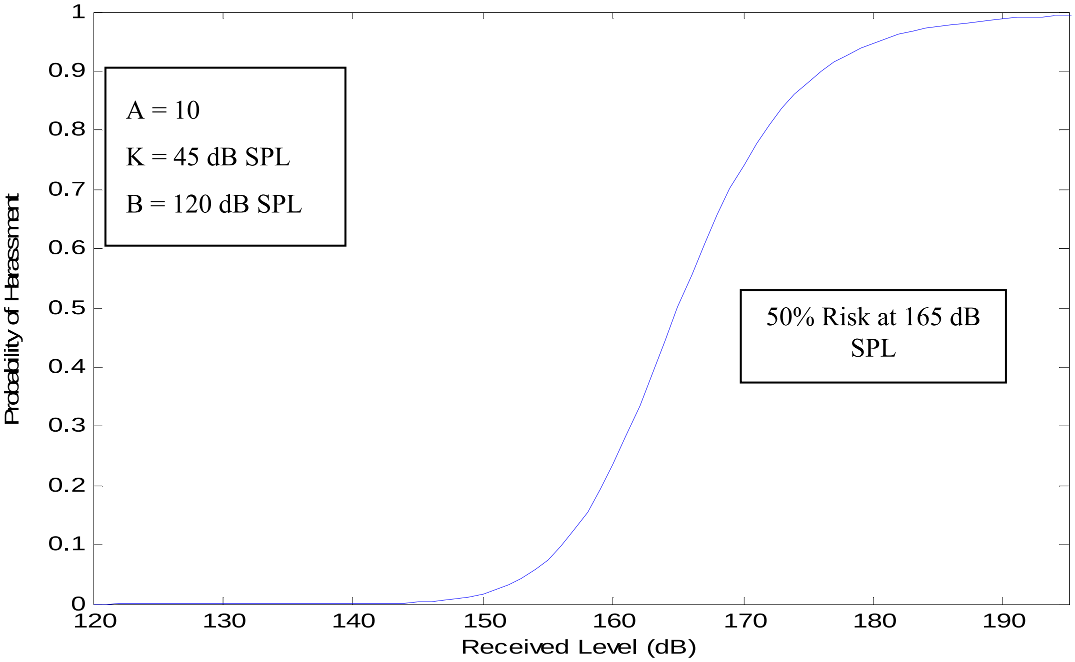


Figure 6-7. Risk Function Curve for Odontocetes (Toothed Whales) and Pinnipeds

Justification for the Steepness Parameter of A=10 for the Odontocete Curve

The NMFS independent review process described in Section 4.1.2.4.9 of DoN (2008) provided the impetus for the selection of the parameters for the risk function curves. One scientist recommended staying close to the risk continuum concept as used in the SURTASS LFA sonar EIS. This scientist opined that both the basement and slope values; B=120 dB and A=10 respectively, from the SURTASS LFA sonar risk continuum concept are logical solutions in the absence of compelling data to select alternate values supporting the Feller-adapted risk function for MFA sonar. Another scientist indicated a steepness parameter needed to be selected, but did not recommend a value. Four scientists did not specifically address selection of a slope value. After reviewing the six scientists' recommendations, the two NMFS scientists recommended selection of A=10. Direction was provided by NMFS to use the A=10 curve for odontocetes based on the scientific review of potential risk functions developed for the HRC EIS/OEIS (Section 4.1.2.4.9.2 of DoN 2008; NOAA 2009).

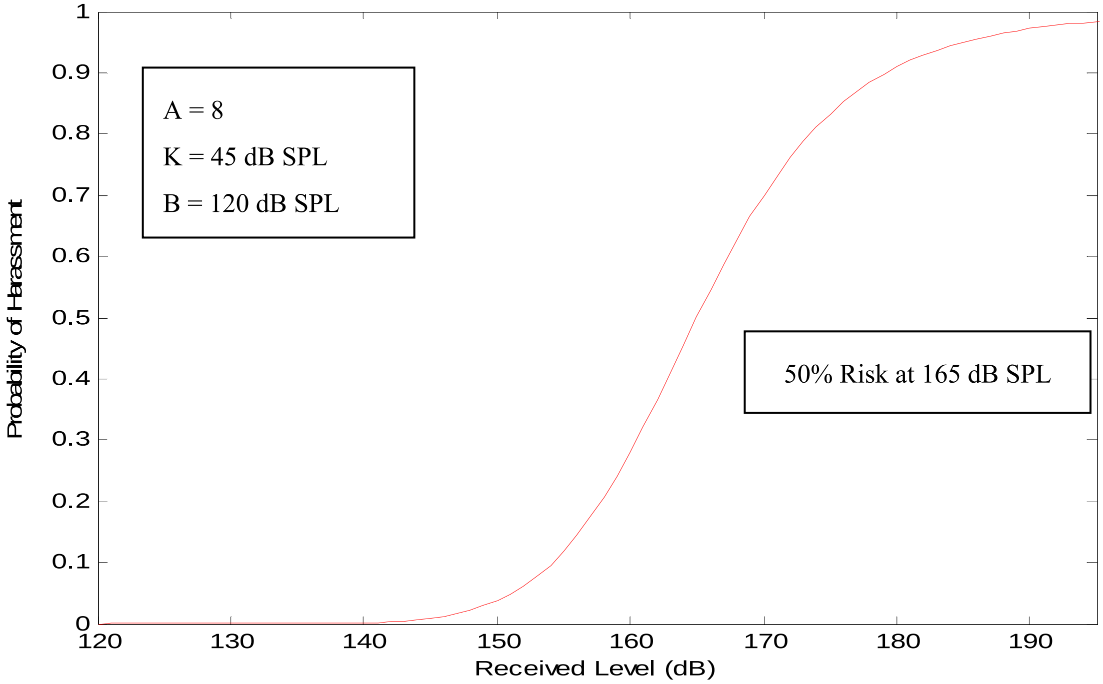


Figure 6-8. Risk Function Curve for Mysticetes (Baleen Whales)

As background, a sensitivity analysis of the A=10 parameter was undertaken and presented in Appendix B of the SURTASS/LFA FEIS (DoN 2001). The analysis was performed to support the A=10 parameter for mysticete whales responding to a low-frequency sound source, a frequency range to which the mysticete whales are believed to be most sensitive to. The sensitivity analysis results confirmed the increased risk estimate for animals exposed to sound levels below 165 dB. Results from the Low Frequency Sound Scientific Research Program (LFS SRP) phase II research showed that whales (specifically gray whales in their case) did scale their responses with received level as supported by the A=10 parameter (Buck and Tyack, 2000). In the second phase of the LFS SRP research, migrating gray whales showed responses similar to those observed in earlier research (Malme et al. 1983, 1984) when the low frequency source was moored in the migration corridor (1.1 nm [2 km] from shore). The study extended those results with confirmation that a louder SL elicited a larger scale avoidance response. However, when the source was placed offshore (2.2 nm [4 km] from shore) of the migration corridor, the avoidance response was not evident. This implies that the inshore avoidance model – in which 50 percent of the whales avoid exposure to levels of 141 + 3 dB – may not be valid for whales in proximity to an offshore source (DoN 2001). As concluded in the SURTASS LFA Sonar Final OEIS/EIS (DoN 2001), the value of A=10 produces a curve that has a more gradual transition than the curves developed by the analyses of migratory gray whale studies (Malme et al. 1984; Buck and Tyack 2000; and SURTASS LFA Sonar EIS, Subchapters 1.43, 4.2.4.3 and Appendix B; NMFS 2008; NOAA 2009).

Justification for the steepness parameter of A=8 for the Mysticete Curve

The Nowacek et al. (2004) study provides the only available data source for a mysticete species behaviorally responding to a sound source (i.e., alert stimuli) with frequencies in the range of tactical mid-frequency sonar (1-10 kHz), including empirical measurements of RLs. While there are fundamental differences in the stimulus used by Nowacek et al. (2004) and tactical mid-frequency sonar (e.g., source level, waveform, duration, directionality, likely range from source to receiver), they are generally similar in frequency band and the presence of modulation patterns. Thus, while they must be considered with caution in interpreting behavioral responses of mysticetes to mid-frequency sonar, they seemingly cannot be excluded from this consideration given the overwhelming lack of other information. The Nowacek et al. (2004) data indicate that five out the six North Atlantic right whales exposed to an alert stimuli "significantly altered their regular behavior and did so in identical fashion" (i.e., ceasing feeding and swimming to just under the surface). For these five whales, maximum RLs associated with this response ranged from root- mean-square sound (rms) pressure levels of 133-148 dB (re: 1 µPa).

When six scientists (one of them being Nowacek) were asked to independently evaluate available data for constructing a dose response curve based on a solution adapted from Feller (1968), the majority of them (4 out of 6; one being Nowacek) indicated that the Nowacek et al. (2004) data were not only appropriate but also necessary to consider in the analysis. While other parameters associated with the solution adapted from Feller (1968) were provided by many of the scientists (i.e., basement parameter [B], increment above basement where there is 50 percent risk [K]), only one scientist provided a suggestion for the risk transition parameter, A.

A single curve may provide the simplest quantitative solution to estimating behavioral harassment. However, the policy decision, by NMFS-Office of Protected Resources (OPR), to adjust the risk transition parameter from A=10 to A=8 for mysticetes and create a separate curve was based on the fact the use of this shallower slope better reflected the increased risk of behavioral response at relatively low RLs suggested by the Nowacek et al. (2004) data. In other words, by reducing the risk transition parameter from 10 to 8, the slope of the curve for mysticetes is reduced (Figure 6-8). This results in an increase the proportion of the population being classified as behaviorally harassed at lower RLs. It also slightly reduces the estimate of behavioral response probability at quite high RLs, though this is expected to have quite little practical result owing to the very limited probability of exposures well above the mid-point of the function. This adjustment allows for a slightly more conservative approach in estimating behavioral harassment at relatively low RLs for mysticetes compared to the odontocete curve and is supported by the only dataset currently available. It should be noted that the current approach (with A=8) still yields an extremely low probability for behavioral responses at RLs between 133-148 dB, where the Nowacek data indicated significant responses in a majority of whales studied. (Note: Creating an entire curve based strictly on the Nowacek et al. [2004] data alone for mysticetes was advocated by several of the reviewers and considered inappropriate, by NMFS-OPR, since the sound source used in this study was not identical to tactical mid-frequency sonar, and there were only five data points available). The policy adjustment made by NMFS-OPR was also intended to capture some of the additional recommendations and considerations provided by the scientific panel (i.e., the curve should be more data driven and that a greater probability of risk at lower RLs be associated with direct application of the Nowacek et al. 2004 data).

6.2.2.4 Harbor Porpoises

The information currently available regarding these inshore species that inhabit shallow and coastal waters suggests a very low threshold level of response for both captive and wild animals. Threshold levels at which both captive (e.g., Kastelein et al. 2000, 2005b, 2006) and wild harbor porpoises (e.g., Johnston, 2002) responded to sound (e.g., acoustic harassment devices (AHDs), acoustic deterrent devices (ADDs), or other nonpulsed sound sources) is very low (e.g., ~120 dB SPL), although the biological significance of the disturbance is uncertain. Therefore, Navy has not used the risk function curve but has applied a step function threshold of 120 dB SPL to estimate MMPA Level B non-TTS behavioral harassment exposure of harbor porpoises in the TMAA (i.e., assumes that all harbor porpoises exposed to 120 dB or higher MFAS will respond in a way NMFS considers behavioral harassment).

6.2.3 Application of the Risk Function and Current Regulatory Scheme

The risk function is used (in all cases other than the harbor porpoise) to estimate the percentage of an exposed population that is likely to exhibit behaviors that would qualify as MMPA Level B harassment (as that term is defined by the MMPA applicable to military readiness activities, such as the Navy's training and testing with mid- and high-frequency active sonar) at a given received level of sound (NOAA 2009). For example, at 165 dB SPL (dB re: 1µPa rms), the risk (or probability) of harassment is defined according to this function as 50 percent, and Navy/NMFS applies that by estimating that 50 percent of the individuals exposed at that received level are likely to respond by exhibiting behavior that NMFS would classify as behavioral harassment (NOAA 2009). The risk function is not applied to individual animals, only to exposed populations.

The data used to produce the risk function were compiled from four species that had been exposed to sound sources in a variety of different circumstances. As a result, the risk function represents a general relationship between acoustic exposures and behavioral responses that is then applied to specific circumstances. That is, the risk function represents a relationship that is deemed to be generally true, based on the limited, best-available science, but may not be true in specific circumstances. In particular, the risk function, as currently derived, treats the received level as the only variable that is relevant to a marine mammal's behavioral response. However, we know that many other variables—the marine mammal's gender, age, and prior experience; the activity it is engaged in during an exposure event, its distance from a sound source, the number of sound sources, and whether the sound sources are approaching or moving away from the animal—can be critically important in determining whether and how a marine mammal will respond to a sound source (Southall et al. 2007). The data that are currently available do not allow for incorporation of these other variables in the current risk functions; however, the risk function represents the best use of the data that are available (NOAA 2009).

As more specific and applicable data become available, NMFS can use these data to modify the outputs generated by the risk function to make them more realistic (and ultimately, data may exist to justify the use of additional, alternate, or multi-variate functions). As mentioned above, it is known that the distance from the sound source and whether it is perceived as approaching or moving away can affect the way an animal responds to a sound (Wartzok et al. 2003, Southall et al. 2007). In the TMAA, modeling indicates animals exposed to received levels between 120 and 130 dB may be 36 to 57 nm (76 to 105 km) from a sound source; those distances would influence whether those animals might perceive the sound source as a potential threat, and their behavioral responses to that threat (DoN 2008, NOAA 2009). Though there are data showing marine mammal responses to sound sources at that received level, NMFS does not currently have any data that describe the response of marine mammals to sounds at that distance (or to other contextual aspects of the exposure, such as the presence of higher frequency harmonics), much less data that compare responses to similar sound levels at varying distances (NOAA 2009). However, if data were to become available that suggested animals were less likely to respond (in a manner NMFS would classify as harassment) to certain levels beyond certain distances, or that they were more likely to respond at certain closer distances, Navy will re-evaluate the risk function to try to incorporate any additional variables into the "take" estimates. For distances to MMPA Level B harassments from non-TTS and the percent of MMPA Level B harassments for those distances in the TMAA for an SQS-53 sonar, see Table 6-2 and Figure 6.9.

Table 6-2. Non-TTS MMPA Level B Harassments at Each Received Level Band in the TMAA from SQS-53 Sonar

Received Level (dB SPL)	Distance at which Levels Occur in GOA	Percent of Behavioral Harassments Occurring at Given Levels
Below 138	42 km – 105 km	~ 0 %
138<Level<144	28 km – 42 km	< 1 %
144<Level<150	17 km – 28 km	~1 %
150<Level<156	9 km – 17 km	7 %
156<Level<162	5 km – 9 km	18 %
162<Level<168	2.5 km – 5 km	26 %
168<Level<174	1.2 km – 2.5 km	22 %
174<Level<180	0.5 km – 1.2 km	14 %
180<Level<186	335 m – 0.5 km	6 %
186<Level<TTS	178 m – 335 m	5 %

Notes: dB = decibel, GOA = Gulf of Alaska, km = kilometer, TMAA = Temporary Maritime Activities Area, MMPA = Marine Mammal Protection Act, nm = nautical mile, SPL = Sound Pressure Level

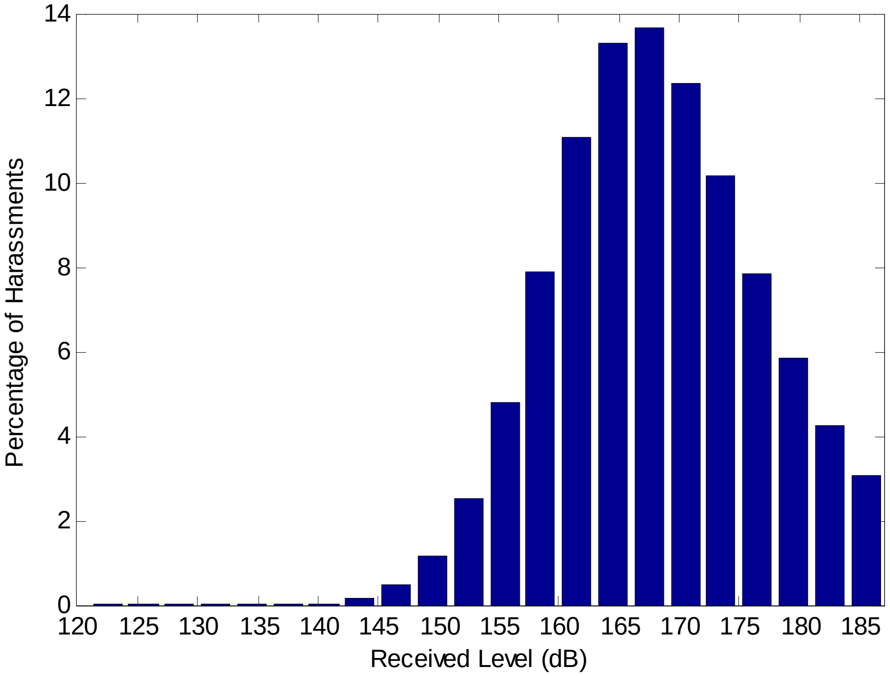


Figure 6-9. The Percentage of MMPA Level B Harassments from Non-TTS for Every 3 dB of Received Level In the TMAA

It is worth noting that Navy and NMFS would expect an animal exposed to the levels at the bottom of the risk function to exhibit non-TTS MMPA Level B harassment behavioral responses that are less likely to adversely affect the longevity, survival, or reproductive success of the animals that might be exposed, based on received level, and the fact that the exposures will occur in the absence of some of the other contextual variables that would likely be associated with increased severity of effects, such as the proximity of the sound source(s) or the proximity of other vessels, aircraft, submarines, etc. maneuvering in the vicinity of the exercise. NMFS will consider all available information (other variables, etc.), but all else being equal, takes that result from exposure to lower received levels and at greater distances from the exercises would be less likely to contribute to population level effects (NMFS 2008, NOAA 2009).

6.3 NAVY PROTOCOLS FOR ACOUSTIC MODELING ANALYSIS OF MARINE MAMMAL EXPOSURES

The quantification of the acoustic modeling results for sonar includes additional analysis to increase the accuracy of the number of marine mammals affected. Table 6-3 provides a summary of the modeling protocols used in the standard Navy analysis. Modeling for ASW and other sound generating activities in the TMAA differ from these protocols in that the annual required sonar hours data was derived from projected future needs based on input gathered during previous Northern Edge Exercise planning conferences and discussions with U.S. Navy Third Fleet training directorate. Post modeling analysis includes reducing acoustic footprints where they encounter land masses, accounting for acoustic footprints for sources that overlap to accurately sum the total area when multiple ships are operating together, and to better account for the maximum number of individuals of a species that could potentially be exposed to sound sources within the course of one day or a discreet continuous event.

Table 6-3. Navy Protocols Providing for Modeling Quantification of Marine Mammal Exposures to Sonar

Historical Data	Sonar Positional Reporting System (SPORTS)	Annual active sonar usage data is obtained from the SPORTS database to determine the number of active sonar hours and the geographic location of those hours for modeling purposes.
Acoustic Parameters	SQS-53 and SQS-56	The SQS-53 and the SQS-56 active sonar sources are modeled separately to account for the differences in source level, frequency, and exposure effects.
	Submarine Sonar	Submarine active sonar use during ASW or ASUW is included in effects analysis calculations using the SPORTS database.
Post Modeling Analysis	Land Shadow	For sound sources within the acoustic footprint of land, the land area is subtracted from the marine mammal exposure calculation.
	Multiple Ships	Correction factors are used to address the maximum potential of exposures to marine mammals resulting from multiple counting based on the acoustic footprint when there are occasions for more than one ship operating within approximately 76 nm (140 km) of one another.
	Multiple Exposures	Accurate accounting for TMAA training events within the course of one day or a discreet continuous sonar event:

Notes: ASW = Anti-submarine Warfare, ASUW = Anti-Surface Warfare, GOA = Gulf of Alaska, km = kilometer, TMAA = Temporary Maritime Activities Areas, nm = nautical mile

6.4 ANALYTICAL FRAMEWORK FOR ASSESSING MARINE MAMMAL RESPONSE TO AT-SEA EXPLOSIONS

The effects of an at-sea explosion on a marine mammal depends on many factors, including the size, type, and depth of both the animal and the explosive charge; the depth of the water column; the standoff distance between the charge and the animal; and the sound propagation properties of the environment. Potential impacts can range from brief acoustic effects (such as behavioral disturbance), tactile perception, physical discomfort, slight injury of the internal organs and the auditory system, to death of the animal (Yelverton et al. 1973, O'Keeffe and Young 1984, DoN 2001). Non-lethal injury includes slight injury to internal organs and the auditory system; however, delayed lethality can be a result of individual or cumulative sublethal injuries (DoN 2001a). Short-term or immediate lethal injury would result from massive combined trauma to internal organs as a direct result of proximity to the point of detonation (DoN 2001a).

6.4.1 Criteria

The criterion for mortality for marine mammals is "onset of severe lung injury" as presented in the Final Rule for the Hawaii Range Complex MMPA Letter of Authorization (NOAA 2009). This is conservative in that it corresponds to a 1 percent chance of mortal injury, and yet any animal experiencing onset severe lung injury is counted as a lethal exposure.

- The threshold is stated in terms of the Goertner (1982) modified positive impulse with value "indexed to 31 psi-ms."" Since the Goertner approach depends on propagation, source/animal depths, and animal mass in a complex way, the actual impulse value corresponding to the 31-psi-ms index is a complicated calculation. Again, to be conservative, CHURCHILL used the mass of a calf dolphin (at 26.4 pound [lb] [12.2 kilogram {kg}]), so that the threshold index is 30.5 pounds per square inch (psi)-ms (Table 6-4).
- Two criteria are used for injury: onset of slight lung hemorrhage and 50 percent eardrum rupture (tympanic membrane [TM] rupture). These criteria are considered indicative of the onset of injury (Table 6-4).
- The threshold for onset of slight lung injury is calculated for a small animal (a dolphin calf weighing 27 lb [12 kg]), and is given in terms of the "Goertner modified positive impulse," indexed to 13 psi-ms in the (DoN 2001a, 2008d). This threshold is conservative since the positive impulse needed to cause injury is proportional to animal mass, and therefore, larger animals require a higher impulse to cause the onset of injury.
- The threshold for TM rupture corresponds to a 50 percent rate of rupture (i.e., 50 percent of animals exposed to the level are expected to suffer TM rupture); this is stated in terms of an SEL value of 205 dB re 1 μPa^2-s. The criterion reflects the fact that TM rupture is not necessarily a serious or life-threatening injury, but is a useful index of possible injury that is well correlated with measures of permanent hearing impairment (e.g., Ketten 1998 indicates a 30 percent incidence of PTS at the same threshold).

Table 6-4. Effects Analysis Criteria for At-Sea Explosions

	Criterion	Metric	Threshold	Comments
Mortality	Mortality Onset of extensive lung hemorrhage	Shock Wave Goertner modified positive impulse	30.5 psi-msec*	All marine mammals (dolphin calf)
Level A Harassment	Slight Injury Onset of slight lung hemorrhage	Shock Wave Goertner modified positive impulse	13.0 psi-msec*	All marine mammals (dolphin calf)
	Slight Injury 50 percent Tympanic Membrane (TM) Rupture	Shock Wave Sound Exposure Level (SEL) for *any single exposure*	205 dB re:1µPa^2-sec	All marine mammals
Level B Harassment	TTS Temporary Auditory Effects	Noise Exposure greatest SEL in any 1/3-octave band *over all exposures*	182 dB re:1µPa^2-sec	For odontocetes greatest SEL for frequencies ≥100 Hz and for mysticetes ≥10 Hz
	TTS Temporary Auditory Effects	Noise Exposure Peak Pressure	23 psi	All marine mammals
	Sub-TTS Behavioral Disturbance (MSE only)	Noise Exposure greatest SEL in any 1/3-octave band *over all exposures*	177 dB re:1µPa^2-sec	For odontocetes greatest SEL for frequencies ≥100 Hz and for mysticetes ≥10 Hz

Notes: Goertner 1982. Prediction of at-sea explosion safe ranges for sea mammals. Naval Surface Weapons Center, White Oak Laboratory, Silver Spring, MD. NSWC/WOL TR-82-188. 25 pp.

DoN, 2001a. USS Churchill Shock Trail FEIS- February, 2001.

NMFS. Briefed to NMFS for VAST-IMPASS.

dB re 1µPa^2-s = decibels referenced to 1 micropascal squared per second, Hz = hertz

MSE = Multiple Successive Explosions, msec = millisecond

psi = pounds per square inch, SEL = Sound Exposure Level

TM = Tympanic membrane, TTS = Temporary Threshold Shift

The following criterion is considered for noninjurious harassment TTS, which is a temporary, recoverable, loss of hearing sensitivity (NMFS 2001, DoN 2001a, NOAA 2009).

- A threshold of 12 psi peak pressure was developed for 10,000-lb charges as part of the CHURCHILL Final EIS (DoN 2001a, [FR70/160, 19 Aug 05; FR 71/226, 24 Nov 06]). It was introduced to provide a more conservative safety zone for TTS when the explosive or the animal approaches the sea surface (for which case the explosive energy is reduced but the peak pressure is not). Navy policy with concurrence from NMFS is to use a 23 psi criterion for explosive charges less than 2,000 lb (907 kg) and the 12 psi criterion for explosive charges larger than 2,000 lb (907 kg). This is below the level of onset of TTS for an odontocete (Finneran et al. 2002). All explosives modeled for the TMAA are less than 1,500 lb (608 kg).
- A threshold of 182 dB re:1µPa^2-sec for any 1/3 octave band over all exposures.

The approximate nominal radial distance from various at-sea explosives to these thresholds in the TMAA during the summer time-frame are presented In Table 6-5.

Table 6-5. Approximate Distance to Effects for At-Sea Explosives in the TMAA

Explosive Source	MMPA Level B Harassment (behavioral disturbance)			MMPA Level A Harassment (slight injury)		Severe Injury or Mortality
	Sub-TTS, 177 dB re 1 μPa^2-s	TTS, 182 dB re 1 μPa2-s	TTS, 23 psi peak pressure	50 percent TM rupture, 205 dB re 1 μPa^2-s	Lung injury, 13 psi-ms	30.5 psi-ms impulse pressure
MK-82	2720	1584	809	302	263	153
MK-83	4056	2374	1102	468	330	195
MK-84	5196	3050	1327	611	378	226
76 mm	168	95	150	19	25	13
5 inch	413	227	269	43	44	23
SSQ-110A sonobuoy (EER/IEER)	NA	325	271	71	135	76

Notes: dB re 1 μPa^2-s = decibels referenced to 1 micropascal squared per second, EER = Extended Echo Ranging, IEER = Improved Extended Echo Ranging, mm = millimeters, MMPA = Marine Mammal Protection Act, psi = pounds per square inch, psi-ms= pounds per square inch per millisecond, TM = Tympanic Membrane, TTS = Temporary Threshold Shift

6.4.2 MMPA Sub-TTS Behavioral Harassment Threshold for Multiple Successive Explosions (MSE)

There may be rare occasions when multiple successive explosions are part of a static location event such as during SINKEX, BOMBEX, or GUNEX (when using other than inert weapons). For MSEs, 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 as first presented in Churchill (DoN 2001). For positive impulse, NMFS has determined it is consistent with Churchill to use the maximum value over all impulses received (NOAA 2009).

For MSE, the acoustic criterion for sub-TTS MMPA Level B harassment 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. The threshold for MMPA Level B harassment from sub-TTS is derived following the approach NMFS has established for the energy-based TTS threshold (NOAA 2009).

The research on pure tone exposures reported in Schlundt et al. (2000) and Finneran and Schlundt (2004) provided the pure-tone threshold of 192 dB as the lowest TTS value. This value is modified for explosives by (a) interpreting it as an energy metric, (b) reducing it by 10 dB to account for the time constant of the mammal ear, and (c) measuring the energy in 1/3 octave bands, the natural filter band of the ear. The resulting TTS threshold for explosives is 182 dB re 1 mPa^2-s in any 1/3 octave band. As reported by Schlundt et al. (2000) and Finneran and Schlundt (2004), instances of altered behavior in the pure tone research generally began five dB lower than those causing TTS. The threshold is therefore derived by subtracting five dB from the 182 dB re 1 mPa^2-s in any 1/3 octave band threshold, resulting in a 177 dB re 1 μPa^2-s sub-TTS MMPA Level B harassment threshold for multiple successive explosives that may result in behavioral disturbance (NOAA 2009).

6.5 ENVIRONMENTAL CONSEQUENCES

This section discusses the potential environmental effects associated with the use of active sonar and other Navy training activities within the TMAA. In determining the potential environmental consequences, an approach was established to differentiate between significant and non-significant effects. This approach involved using either documented regulatory criteria or the best scientific information available at the time of analysis. Further, the extent of significance was evaluated using the context (e.g., short- versus long-term) of the Proposed Action and the intensity (severity) of the potential effect.

6.6 ACOUSTIC IMPACT MODEL PROCESS APPLICABLE TO ALL ALTERNATIVE DISCUSSIONS

The methodology for analyzing potential impacts from sonar and explosives is presented in Appendix B, which explains the modeling process in detail, describes how the impact threshold derived from Navy-NMFS consultations are derived, and discusses relative potential impact based on species biology.

The Navy acoustic exposure model process uses a number of inter-related software tools to assess potential exposure of marine mammals to Navy generated underwater sound including sonar and explosions. For sonar, these tools estimate potential impact volumes and areas over a range of thresholds for sonar specific operating modes. Results are based upon extensive pre-computations over the range of acoustic environments that might be encountered in the operating area (Appendix B).

The acoustic model includes four steps used to calculate potential exposures:

1. Identify unique acoustic environments that encompass the operating area. Parameters include depth and seafloor geography, bottom characteristics and sediment type, wind and surface roughness, sound velocity profile, surface duct, sound channel, and convergence zones.

2. Compute transmission loss (TL) data appropriate for each sensor type in each of these acoustic environments. Propagation can be complex depending on a number of environmental parameters listed in step one, as well as sonar operating parameters such as directivity, source level, ping rate, and ping length, and for explosives the amount of explosive material detonated. The standard Navy Comprehensive Acoustic Simulation System/Gaussian Ray Bundle (CASS-GRAB) acoustic propagation model is used to resolve complexities for underwater propagation prediction.

3. Use that TL to estimate the total sound energy received at each point in the acoustic environment.

4. Apply this energy to predicted animal density for that area to estimate potential acoustic exposure, with animals distributed in 3-D based on best available science on animal dive profiles.

6.7 MODEL RESULTS EXPLANATION

A large body of research on terrestrial animal and human response to airborne sound exists, but results from those studies are not readily applicable to the development of behavioral criteria and thresholds for marine mammals. Differences in hearing thresholds, dynamic range of the ear, and the typical exposure patterns of interest (e.g., human data tend to focus on 8-hour-long exposures), and the difference between acoustics in air and in water make extrapolation of human sound exposure standards inappropriate.

For purposes of predicting potential acoustic and explosive effects on marine mammals, the Navy uses an acoustic impact model process with numeric criteria agreed upon with the NMFS (NOAA 2009). While this process is described more completely in Appendix B, there are some caveats necessary to understand in order to put these exposures in context and used in recent Final Rules (NOAA 2008b, 2008c).

For instance, (1) significant scientific uncertainties are implied and carried forward in any analysis using marine mammal density data as a predictor for animal occurrence within a given geographic area; (2) there are limitations to the actual model process based on information available (animal densities, animal depth distributions, animal motion data, impact thresholds, and supporting statistical model); and (3) determination and understanding of what constitutes a significant behavioral effect is still unresolved.

The sources of marine mammal densities used in this analysis are derived from NMFS broad scale surveys. However, although survey design includes statistical placement of survey tracks, the survey itself can only cover so much ocean area and post-survey statistics are used to calculate animal abundances and densities (Barlow and Forney 2007). There is often significant statistical variation inherit within the calculation of the final density values depending on how many sightings were available during a survey.

Occurrence of marine mammals within any geographic area, such as the TMAA, is highly variable and strongly correlated to parameters such as oceanographic conditions, prey availability, and ecosystem level patterns rather than broad changes in a stock's reproduction success and survival (Forney 2000, Ferguson and Barlow 2001, Benson et al. 2002, Moore et al. 2002, Tynan 2005, Redfern 2006). For some species, distribution may be even more highly influence by relative small scale features over both short and long-term time scales (Balance et al. 2006, Etnoyer et al. 2006, Ferguson et al. 2006, Skov et al. 2007). Unfortunately, the scientific level of understanding of some large scale and most small scale processes thought to influence marine mammal distribution is incomplete.

Given the uncertainties in marine mammal density estimation and localized distributions, the Navy's acoustic impact models can not currently be used to predict occurrence of marine mammals within specific regions of the GOA. To resolve this issue and allow modeling to proceed, animals are uniformly distributed within acoustic modeling provinces as described in Appendix B. This process does not account for animals that move into or out of the region based on foraging and migratory patterns, and adds a significant amount of variability to the model predictions. Parameters have, therefore, been chosen to err on the side of overestimation.

Results, therefore, from acoustic impact exposure models should be regarded as exceedingly conservative estimates strongly influenced by limited biological data. While numbers generated allow establishment of predicted marine mammal exposures for consultation with NMFS, the short duration and limited geographic extent of most sonar and at-sea explosive events does not necessarily mean that these exposures will in fact occur.

6.8 BEHAVIORAL RESPONSES

Behavioral responses to exposure from MFA and HFA sonar, other non-sonar acoustic sources, and at-sea explosions can range from no observable response to panic, flight and possibly stranding (Figure 6-8) (NOAA 2009). Recent behavioral response study field experiments with tagged beaked whales found their reactions to MFA sonar consisted of the animals stopping their clicking, producing fewer foraging buzzes than normal, and ending their dives in a long and an unusually slow ascent moving away from the sound source (Tyack 2009). It was further suggested based on these response studies that beaked whales may be "particularly sensitive to anthropogenic sounds, but there is no evidence that they have a special sensitivity to sonar compared with other signals" (Tyack 2009)

It has been long recognized that the intensity of the behavioral responses exhibited by marine mammals depends on a number of conditions including the age, reproductive condition, experience, behavior (foraging or reproductive), species, received sound level, type of sound (impulse or continuous) and duration of sound (Reviews by Richardson et al. 1995, Wartzok et al. 2003, Cox et al. 2006, Nowacek et al. 2007, Southall et al. 2007). Many behavioral responses may be short term (seconds to minutes) and of little immediate consequence for the animal such as simply orienting to the sound source. Alternatively, there may be a longer term response over several hours such as moving away from the sound source. In addition, some responses have the potential life function consequences such as leading to a stranding or a mother-offspring separation (Baraff and Weinrich 1994, Gabriele et al. 2001). Generally the louder the sound source the more intense the response although duration, context, and disposition of the animal are also very important (Southall et al. 2007). Exposure to loud sounds resulting from Navy training would be brief as the ship and other participants are constantly moving and the animal will likely be moving as well.

According to the severity scale response spectrum proposed by Southall et al. (2007) (Figure 6-10), responses classified as from 0-3 are brief and minor, those from 4-6 have a higher potential to affect foraging, reproduction, or survival and those from 7-9 are likely to affect foraging, reproduction and survival. Sonar and explosive mitigation measures (sonar power-down or shut-down zones and explosive exclusion zones) would likely prevent animals from being exposed to the loudest sonar sounds or explosive effects that could potentially result in TTS or PTS and more intense behavioral reactions (i.e., 7-9) on the response spectrum.

There are little data on the consequences of sound exposure on vital rates of marine mammals. Several studies have shown the effects of chronic noise (either continuous or multiple pulses) on marine mammal presence in an area exposed to seismic survey airguns or ship noise (e.g., Malme et al. 1984, McCauley et al. 1998, Nowacek et al. 2004). MFA sonar use in Navy ranges is not new and has occurred using the same basic sonar equipment and output for over approximately 30 years. Given this history the Navy believes that risk to marine mammals from sonar training is low.

Even for more cryptic species such as beaked whales, the main determinant of causing a stranding appears to be exposure in a limited egress area (a long narrow channel) with multiple ships. This would be consistent with the recent suggestion that beaked whales are not particularly sensitive to sonar but tend to move away from all anthropogenic noise (Tyack 2009). When animals are unable to avoid the exposure because of constructed bathymetry and multiple ships, in these specific circumstances and conditions MFA sonar is believed to have contributed to the stranding and mortality of a small number of beaked whales in locations other than the GOA. There are no limited egress areas (long narrow channels) or landmasses within the TMAA, therefore, it is unlikely that the proposed sonar use would result in any strandings. Although the Navy has substantially changed operating procedures to avoid the aggregate of circumstances that may have contributed to previous strandings, it is important that future unusual stranding events be reviewed and investigated so that any human cause of the stranding can understood and avoided.

There have been no known beaked whale strandings in the GOA associated with the use of MFA/HFA sonar by fisheries research activities or seismic research. There are critical contextual difference between the TMAA and areas of the world where strandings have occurred (Southall et al. 2007). While the absence of evidence does not prove there have been no impacts on beaked whales where sonar has been used previously, decades of use of sonar in Navy concentration areas (e.g., Southern California, the Atlantic Coast, Gulf of Mexico) with no evidence of beaked whale strandings with MFA sonar, or indications of effects to species or populations should be given consideration.

0 -No observable response
1 -Brief orientation response (investigation / visual orientation)
2 -Moderate or multiple orientation behaviors
-Brief or minor cessation/ modification of vocal behavior
-Brief or minor change in respiration rates
3 -Prolonged orientation behavior
-Individual alert behavior
-Minor changes in locomotion speed, direction, and/or dive profile but no avoidance of sound source
-Moderate change in respiration rate
-Minor cessation or modification of vocal behavior (duration < duration of source operation), including the Lombard Effect
4 -Moderate changes in locomotion speed, direction, and/or dive profile, but no avoidance of sound source
-Brief, minor shift in group distribution
-Moderate cessation or modification of vocal behavior (duration approx duration of source operation)
5 -Extensive or prolonged changes in locomotion speed, direction, and/or dive profile but not avoidance of sound source
-Moderate shift in group distribution
-Change in inter-animal distance and/or group size (aggregation or separation)
-Prolonged cessation or modifications of vocal behavior (duration > duration of source operation)
6 -Minor or moderate individual and/or group avoidance of sound source
-Brief or minor separation of females and dependent offspring
-Aggressive behavior related to noise exposure (e.g., tail/flipper slapping, fluke display, jaw clapping/ gnashing teeth, abrupt directed movement, bubble clouds)
-Extended cessation or modification of vocal behavior
-Visible startle response
-Brief cessation of reproductive behavior
7 -Excessive or prolonged aggressive behavior
-Moderate separation of females and dependent offspring
-Clear anti-predator response
-Severe and/ or sustained avoidance of sound source
-Moderate cessation of reproductive behavior
8 -Obvious aversion and/or progressive sensitization
-Prolonged or significant separation of females and dependent offspring with disruption of acoustic reunion mechanisms
-Long-term avoidance of area (> source operation)
-Prolonged cessation of reproductive behavior
9 -Outright panic, flight, stampede, attach of conspecifics, or stranding events
-Avoidance behavior related to predator detection

**1-3
DEFINED BY NMFS
AS NO MMPA
BEHAVIORAL
HARASSMENT**

**7-9
DEFINED BY NMFS
AS MMPA
BEHAVIORAL
HARASSMENT
Plus subset
behaviors in 4 to 6
depending on
context
of behavior**

Figure 6-10. Marine Mammal Response Spectrum to Anthropogenic Sounds (numbered severity scale for ranking observed behaviors from Southall et al. 2007)

6.9 TTS

A TTS is a temporary recoverable, loss of hearing sensitivity over a small range of frequencies related to the sound source to which it was exposed. The animal may not even be aware of the TTS and does not become deaf, but requires a louder sound stimulus (relative to the amount of TTS) to detect that sound within the affected frequencies. TTS may last several minutes to several days and the duration is related to the intensity of the sound source and the duration of the sound (including multiple exposures). Sonar exposures from ASW training are generally short in duration and intermittent (several sonar pings per minute from a moving ship), and with mitigation measures in place, TTS in marine mammals exposed to MFA or HFA sonar or other sound sources and at-sea explosions are unlikely to occur. There is currently no information to suggest that if an animal has TTS, that it will decrease the survival rate or reproductive fitness of that animal. TTS range from an SQS-53 sonar’s 235 dB source level one second ping is approximately 584 ft (178 m) from the bow of the ship under nominal oceanographic conditions during the summer in the TMAA.

6.10 PTS

A PTS is non-recoverable, results from the destruction of tissues within the auditory system and occurs over a small range of frequencies related to the sound exposure. The animal does not become deaf but requires a louder sound stimulus (relative to the amount of PTS) to detect that sound within the affected frequencies. Sonar exposures are general short in duration and intermittent (several sonar pings per minute from a moving ship), and with mitigation measures in place, PTS in marine mammals exposed to MFA or HFA sonar is very unlikely to occur. There is currently no information to suggest that if an animal has PTS that it decrease the survival rate or reproductive fitness of that animal. The distance to PTS from an SQS-53 sonar's 235 dB source level and one second ping is approximately 33 ft (10 m) from the bow of the ship under nominal oceanographic conditions in the TMAA.

6.11 POPULATION LEVEL EFFECTS

Some Navy training activities will be conducted in the same general areas across the 42,146 nm^2 (145,482 km^2) of the TMAA over a 21-day (maximum) exercise period, so marine mammal populations could be exposed to activities more than once over the period of the exercise. The acoustic analyses assume that short-term non-injurious sound levels predicted to cause TTS and/or non-TTS behavioral disruptions qualify as MMPA Level B harassment. Based on previous findings from NMFS, however, it is unlikely that most behavioral disruptions or instances of TTS will result in long-term significant effects (NMFS 2008, NOAA 2009). Mitigation measures reduce the likelihood of exposures to sound levels that would cause significant behavioral disruption (the higher levels of 7-9 in Figure 6-10), TTS or PTS. Based on acoustic modeling the Navy has estimated that a total of 424,617 marine mammals per year might be behaviorally disturbed resulting in MMPA Level B harassment from the proposed training activities in the TMAA. The Navy does not anticipate any mortality to result from the proposed training. It is unlikely that the short-term behavioral disruption would adversely affect the species or stock through effects on annual rates of recruitment or survival.

6.11.1 Non-Sonar Acoustic Impacts and Non-Acoustic Impacts

6.11.1.1 Ship Noise

Increased number of ships operating in the area will result in increased sound from vessel traffic. Marine mammals react to vessel-generated sounds in a variety of ways. Some respond negatively by retreating or engaging in antagonistic responses while other animals ignore the stimulus altogether (Watkins, 1986; Terhune and Verboom, 1999). Most studies have ascertained the short-term response to vessel sound and vessel traffic (Watkins et al. 1981, Baker et al. 1983, Magalhães et al. 2002); however, the long-term implications of ship sound on marine mammals is largely unknown (National Marine Fisheries Service, 2007). Anthropogenic sound, especially around regional commercial shipping hubs has increased in the marine environment over the past 50 years (Richardson et al. 1995, Andrew et al. 2002, National Research Council 2003, Hildebrand 2004, National Research Council 2005). This sound increase can be attributed primarily to increases in vessel traffic as well as sound from other human sources (Richardson et al. 1995, National Research Council 2005). National Research Council (2005) has a thorough discussion of both human and natural underwater sound sources.

Given the current ambient sound levels in the GOA marine environment from fishing vessels and other commercial traffic, the additional sound contributed by Navy vessels in the proposed exercises is very low. In addition, as opposed to commercial vessels, Navy ships are purposely designed and engineered for the lowest underwater acoustic signature possible given the limits of current naval shipbuilding technology. The goal with ship silencing technology is to limit the amount of sound a Navy vessel radiates that could be used by a potential adversary for detection. Given these factors, it is anticipated that any marine mammals in the vicinity of Navy ships may exhibit either no reaction or only short-term reactions, and would not suffer any long-term consequences from ship sound.

6.11.1.2 Collisions with Whales

Vessel collisions are an acknowledged source of mortality and injury to all large whales. A discussion of the information available regarding collisions or "ship strikes" as related to individual large whale species in the TMAA has been presented in Sections 3.8.3 and 3.8.4.

Under the preferred alternative and with regard to annual Navy vessel traffic, the Navy has proposed providing the flexibility to conduct (as required) a second summer exercise within the TMAA between 2010 and 2015. Within the maximum two summer exercises, the length of the exercise, the number of vessels, and the allotted at-sea time within the TMAA during an exercise will be variable between years. These variations cannot be predicted given unknowns including the availability of participants for the annual exercise(s), which is a direct result of factors such as Navy responses to real-world events (e.g., tactical deployments, disaster relief, humanitarian assistance, etc.), planned and unplanned deployments, vessel availability due to funding and maintenance cycles, and logistic concerns with conducting an exercise in the GOA. The Navy predicts, however, there will be no increase required in excess of two annual summer exercises as described for Alternative 2 over the course of the 2010 and 2015 timeframe such that it is unlikely increases in steaming days would occur during this time period.

The following paragraphs present a context and assessment for the potential for Navy ship strikes in the TMAA. Accurate data regarding vessel collisions with whales is difficult for several reasons but mainly due to a lack of mandatory reporting by vessels other than the U.S. Navy and Coast Guard (Navy and Coast Guard report all whale collisions to NMFS as a standard procedure). As a result, historic trends, annual rates of collision, and, most importantly, the effect vessel collisions may have on particular stocks of whales or other marine mammals remain unknown.

The Navy requires reporting of all collisions involving marine mammals. While recognizing Navy activity in the TMAA has previously involved no more than an annual brief three-week period in the summer, there have been no known collisions, referred to as “ship strikes” by Navy vessels in Alaska waters over many years of operation.

Reviews of the record, involving mostly commercial vessel collisions between ships and whales have been published (e.g., Laist et al. 2001, Jensen and Silber 2004). However, Navy vessel operations differ from commercial vessels in a number of ways important to the prevention of whale collisions. Navy surface ships maintain a constant, 24/7 navigation watch with dedicated lookouts while underway. The Navy has developed a Marine Species Awareness Training, which is required for all lookouts and is designed to recognize marine mammal cues to assist in avoiding potential collisions with whales. In addition to lookouts, there are often other watchstanders such as ship officers and supervisory personnel, as well as lookouts responsible for safe navigation and avoidance of in-water objects (marine mammals, other vessels, flotsam, marine debris, etc.). There are numerous reports from Navy transits and exercises in other locations involving the detection of whales with vessels subsequently proactively maneuvering to avoid a collision with a whale. For the safety of the crew, stewardship of marine mammals, and to avoid damage to vessels, the Navy does what it can to avoid ship strikes.

For Alaska waters, the available whale-vessel collision data has been presented in an unpublished preliminary summary (Gabriele et al. manuscript on file). The summary presents an opportunistically collected record containing reports of 62 whale-vessel collisions between 1978 and 2006 with most occurring in Southeast Alaska. This report is likely biased toward near shore reports and inland waters of Southeast Alaska where the authors were located and where nearshore vessels and a population of humpback whales overlap. Only one collision was recorded within the TMAA (involving a fishing vessel/sperm whale). As is evident from the Alaska record, most known collisions in Alaska waters involve humpback whales, although worldwide historical records indicate fin whales were the most likely species to be struck (Laist et al. 2001). Most of the TMAA is above deep water and well offshore, which is not the preferred habitat for humpback whales, but is an area where fin whales or other species may certainly be present.

The following Navy requirements are intended to reduce the likelihood of a collision with whales. Naval vessels will maneuver to keep at least 1,500 ft (500 yds) away from any observed whale in the vessel's path and avoid approaching whales head-on. These requirements do 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. Vessels will take all practicable steps to alert other vessels in the vicinity of the whale.

In summary, fin, humpback and other large whales may be present in the TMAA, but the sparse available data on whale-vessel collisions indicates that collisions are unlikely overall. The risk of collision is further reduced by the short duration of the exercise, Navy protocols for maintaining a lookout at all times, and maneuvering to avoid whales when possible. Given these factors, it is unlikely that Navy training activities in the TMAA would result in a collision with a whale.

6.11.1.3 Disturbance Associated with Vessel Movements

As noted previously, variations in these maximum number of vessels participating cannot be predicted given unknowns including the availability of vessels for the annual exercise(s). In addition to the potential for collisions with marine mammals, vessel movements have the potential to affect marine mammals by directly striking or disturbing individual animals. The probability of vessel and marine mammal interactions occurring in the TMAA is dependent upon several factors including numbers, types, and speeds of vessels; the regularity, duration, and spatial extent of activities; the presence/absence and density of marine mammals; and protective measures implemented by the Navy. During training activities, speeds vary and depend on the specific training activity. In general, Navy vessels will move in a coordinated manner but separated by many miles in distance. These activities are widely dispersed throughout the TMAA, which is a vast area encompassing 42,146 nm^2 (145,458 km^2). Consequently, the density of Navy vessels within the TMAA at any given time is extremely low.

Marine mammals are frequently exposed to vessels traffic as a result of commercial fishing activities, research, ecotourism, commercial and private vessel traffic. The presence of vessels has the potential to alter the behavior patterns of marine mammals. It is difficult to differentiate between responses to vessel sound and visual cues associated with the presence of a vessel; thus, it is assumed that both play a role in prompting reactions from animals (NMFS 2008). Anthropogenic sound has increased in the marine environment over the past 50 years as a result of increased vessel traffic, marine dredging and construction, oil and gas drilling, geophysical surveys, sonar, and at-sea explosions (Richardson et al. 1995, NRC 2003). Vessel strikes are rare, but do occur and can result in injury (NMFS 2008).

Marine mammals react to vessels in a variety of ways and seem to be generally influenced by the activity the marine mammal is engaged in when a vessel approaches (Richardson et al. 1995). Some respond negatively by retreating or engaging in antagonistic responses while other animals ignore the stimulus altogether (Watkins 1986, Terhune and Verboom 1999). The ESA-listed marine mammal species (blue, fin, humpback, North Pacific right, sei, and sperm whales; and Steller sea lion) that occur in the TMAA are not generally documented to approach vessels in their vicinity. The predominant reaction is either neutral or avoidance behavior, rather than attraction behavior. If available, additional information regarding each listed species is provided below.

Blue and Sei Whales

There is little information on blue whale or sei whale response to vessel presence (NMFS 1998a, 1998b). Sei whales have been observed ignoring the presence of vessels and passing close to the vessel (Weinrich et al. 1986). The response of blue and sei whales to vessel traffic is assumed to be similar to that of the other baleen whales, ranging from avoidance maneuvers to disinterest in the presence of vessels. Any behavioral response would be short-term in nature.

Fin and Humpback Whales

Fin whales have been observed altering their swimming patterns by increasing speed, changing their heading, and changing their breathing patterns in response to an approaching vessel (Jahoda et al. 2003). Observations have shown that when vessels remain 328 ft (100 m) or farther from fin and humpback whales, they were largely ignored (Watkins et al. 1981). Only when vessels approached more closely did the fin whales in the study altered their behavior by increasing time at the surface and engaging in evasive maneuvers. The humpback whales did not exhibit any avoidance behavior (Watkins et al. 1981). However, in other instances humpback whales did react to vessel presence. In a study of regional vessel traffic, Baker et al. (1983) found that when vessels were in the area, the respiration patterns of the humpback whales changed. The whales also exhibited two forms of behavioral avoidance when vessels were between 0 and 6,562 ft (2,000 m) away (Baker et al. 1983): 1) horizontal avoidance (changing direction and/or speed) when vessels were between 6,562 ft (2,000 m) and 13,123 ft (4,000 m) away, or 2) vertical avoidance (increased dive times and change in diving pattern).

Based on existing studies, it is likely that fin and humpback whales would have little reaction to vessels that maintain a reasonable distance from the animals. The distance that will provoke a response varies based on many factors including, but not limited to, vessel size, geographic location, and individual animal tolerance levels (Watkins et al. 1981, Baker et al. 1983, Jahoda et al. 2003). Should the vessels approach close enough to invoke a reaction, animals may engage in avoidance behaviors and/or alter their breathing patterns. Reactions exhibited by the whales would be temporary in nature. They would be expected to return to their pre-disturbance activities once the vessel has left the area.

North Pacific Right Whales

Although very little data exists examining the relationship between vessel presence and significant impact to North Pacific right whales, it is thought that any disturbance impacts would be minor and/or temporary in nature (NMFS 2005). In the North Pacific, ship strikes may pose a potential threat to North Pacific right whales. However, because of their rare occurrence and scattered distribution, it is impossible to assess the threat of ship strikes to this species at this time. For these reasons, NMFS has not identified ship collisions as major threat because the estimated annual rate of human-caused mortality and serious injury appears minimal (NMFS: http://www.nmfs.noaa.gov/pr/species/mammals/cetaceans/rightwhale_northpacific.htm, accessed May 30, 2008). Through 2002, there were no reports of ship strikes of North Pacific right whales by large ships along the U.S. West Coast and Canada (Jensen and Silber 2003). In addition, North Pacific right whales are protected through measures such as the 500-yard (1,500-m) no-approach limit, which affords them additional protection and further alleviates any effect vessel traffic might have on behavior or distribution (NMFS 1997).

Sperm Whale

Sperm whales generally show little to no reaction to ships, except on close approaches (within several hundred meters); however, some did show avoidance behavior such as quick diving (Würsig et al. 1998). In addition, in the presence of whale watching and research boats, changes in respiration and echolocation patterns were observed in male sperm whales (Richter et al. 2006). Disturbance from boats did not generally result in a change in behavior patterns and is short-term in nature (Magalhães et al. 2002).

Killer Whale

In Washington and British Columbia beginning in the late 1970s, whale watching involving mainly killer whales has become an important regional tourist industry. Both commercial and private vessels engage in whale watching. The number of vessels engaged in this activity increased from a few boats and fewer than 1,000 passengers annually in the early 1980s to about 41 companies with 76 boats and more than 500,000 passengers annually in 2006 (Koski 2007). The growth of whale watching during the past 20 years has meant that killer whales in the region are experiencing increased exposure to vessel traffic. Not only do greater numbers of boats accompany the whales for longer periods of the day, but there has also been a gradual lengthening of the viewing season. Several studies have linked vessels with short-term behavioral changes in northern and southern resident killer whales (Kruse 1991, Kriete 2002, Williams et al. 2002, Bain et al. 2006), although whether it is the presence and activity of the vessel, the sounds of the vessel or a combination these factors is not well understood. Individual whales have been observed to react in a variety of ways to whale-watching vessels. Responses include swimming faster, adopting less predictable travel paths, making shorter or longer dives, moving into open water, and altering normal patterns of behavior at the surface (Kruse 1991, Williams et al. 2002, Bain et al. 2006), while in some cases, no disturbance seems to occur. Avoidance tactics often vary between encounters and the sexes, with the number of vessels present and their proximity, activity, size, and "loudness" affecting the reaction of the whales (Williams et al. 2002). Avoidance patterns often become more pronounced as boats approach closer.

The potential impacts of whale watching on killer whales remain controversial and inadequately understood. Although numerous short-term behavioral responses to whale watching vessels have been documented, no studies have yet demonstrated a long-term adverse effect from whale watching on the health of any killer whale population in the northeastern Pacific (NMFS 2008). There are no reported instances of killer whale strikes, mortality, or injury reported because of these vessel activities (NMFS 2008).

Delphinids

Species of delphinids can vary widely in their reaction to vessels. Many exhibit mostly neutral behavior, but there are frequent instances of observed avoidance behaviors (Hewitt 1985, Würsig et al. 1998). In addition, approaches by vessels can elicit changes in behavior, including a decrease in resting behavior or change in travel direction (Bejder et al. 2006). Alternately, many of the delphinid species exhibit behavior indicating attraction to vessels. This can include solely approaching a vessel (observed in harbor porpoises and minke whales) (David 2002), but many species such as common, rough-toothed and bottlenose dolphins are frequently observed bow riding or jumping in the wake of a vessel (Norris and Prescott 1961, Shane et al. 1986, Würsig et al. 1998, Ritter 2002). While this is also a regular occurrence wit Navy vessels, in the past, this also occurred when Navy vessels when using mid-frequency active sonar (current mitigation measures now preclude this from occurring). These behavioral alterations are short-term and would not result in any lasting effects.

Expendable Devices

Marine mammals are subject to entanglement in expended material, particularly anything incorporating loops or rings, hooks and lines, or sharp objects. Most documented cases of entanglements occur when whales encounter the vertical lines of fixed fishing gear. This section analyzes the potential effects of expended devices on marine mammals. The Navy employs the use of expendable devices as sensors (i.e., bathythermographs, sonobuoys), targets, and dye markers during training activities and some of these devices or portions of them could potentially be encountered by marine mammals in the waters of the TMAA. Some of these devices are designed not to be recovered and they generally sink to the ocean floor within a short period of time following their intended use. None should remain on or near the sea surface and the density of such devices in the TMAA would be very low. Types of expendable devices or their components that might be encountered by marine mammals include: parachutes of various types (e.g., on targets, flares, or sonobuoys); sonobuoys; flares and markers; and Expendable Mobile ASW Training Target (EMATT). Ingestion of these devices by marine mammals is unlikely based on the information discussed in the following paragraphs.

Entanglement in expendable devices was not cited as a source of injury or mortality for any marine mammals recorded in a large marine mammal and sea turtle stranding database for California waters. Use of expendable devices is highly unlikely to affect marine mammal species in the TMAA. The following discussion addresses categories of expendable devices.

Sonobuoys. A sonobuoy is approximately 5 in (13 cm) in diameter, 3 ft (1 m) long, and weighs between 14 and 39 lbs (6 and 18 kg), depending on the type. In addition, aircraft-launched sonobuoys deploy a nylon parachute of varying sizes, ranging from 1.6 to 3.8 ft2 (0.15 to 0.35 m2). The shroud lines range from 12 to 21 in (0.30 to 0.53 m) in length and are made of either cotton polyester with a 30-lb (13.6-kg) breaking strength or nylon with a 100-lb (45.4-kg) breaking strength. All parachutes are weighted with a 2 ounce (0.06-kg) steel material weight, which causes the parachute to sink from the surface within 15 minutes. At water impact, the parachute assembly, battery, and sonobuoy will sink to the ocean floor where they will be buried into its soft sediments or land on the hard bottom where they will eventually be colonized by marine organisms and degrade over time. These components are not expected to float at the water surface or remain suspended within the water column. Over time, the amount of materials will accumulate on the ocean floor. However, the active sonar activities using sonobuoys will not likely occur in the exact same location each time. Additionally, the materials will not likely settle in the same vicinity due to ocean currents.

Parachutes. Aircraft-launched sonobuoys, flares, torpedoes, and EMATTs deploy nylon parachutes of varying sizes. As described above, at water impact, the parachute assembly is expended and sinks, as all of the material is negatively buoyant. Some components are metallic and will sink rapidly. Entanglement and the eventual drowning of a marine mammal in a parachute assembly would be unlikely, since such an event would require the parachute to land directly on an animal, or the animal would have to swim into it before it sinks. The expended material will accumulate on the ocean floor and will be covered by sediments over time, remaining on the ocean floor and reducing the potential for entanglement. If bottom currents are present, the canopy may billow (bulge) and pose an entanglement threat to marine animals with bottom-feeding habits; however, the probability of a marine mammal encountering a submerged parachute assembly and the potential for accidental entanglement in the canopy or suspension lines is considered to be unlikely.

Expendable Training Targets. In the TMAA, Navy may use EMATT and markers as expendable targets during training.

EMATTs are approximately 5 by 36 inches (in) (12 by 91 centimeters [cm]) and weigh approximately 21 pounds (lbs). Given the small size of EMATTs, coupled with the low probability that an animal would occur at the immediate location of deployment and reconnaissance, provide little potential for a direct strike. EMATTs, their batteries, parachutes, and other components will scuttle and sink to the ocean floor and will be covered by sediments over time. In addition, the small amount of expended material will be spread over a relatively large area.encompassed by the TMAA. Due to the small size of these devices and resultant low density of these materials in the TMAA, these are not expected to affect marine mammals.

The inflatable orange vinyl target called a killer tomato and the towed spar, which each can serve as a training tool during GUNEX, are recovered at the end of their use during a training event and thus have no effect on marine mammals or their habitat.

Based on the above information, there will be no significant impact to marine habitat from expended training targets or their components.

6.11.2 Summary of Potential Sonar Effects

Table 6-6 represents the number of active sonar hours or usage per year for different sonar sources including the SQS-53, SQS-56, BQQ-10, BQS-15, AQS-22 dipping sonar, and SSQ-62 Directional Command Activated Sonobuoy System (DICASS) sonobuoys.

Table 6-6. Summary of the Number of Active Sonar Hours or Usage Per Year for Different Sonar Sources from the Proposed Training Activities

Event	SQS-53 Sonar Hours	SQS-56 Sonar Hours	BQQ-10 Sub Sonar Hours	BQS-15 Sonar Hours	AQS-22 Number of Dips	SSQ-62 DICASS Sonobuoys Deployments
1st Summer Exercise	289	26	24	**12**	96	133
2nd Summer Exercise	289	26	24	**12**	96	133
Preferred Alternative (Total)	**578**	**52**	**48**	**24**	**192**	**266**

Specifically, under this assessment for MFA sonar, the risk function methodology estimates 424,617 (per year) non-TTS MMPA Level B harassment exposures that could potentially result in behavioral disturbance; 931 (per year) MMPA Level B harassment exposures that could potentially result in TTS behavioral disturbance; and one (per year) MMPA Level A harassment exposure resulting in potential injury as PTS. Details regarding the analysis for each species are provided in Table 6-7.

It should be noted, however, that these exposure modeling results are statistically derived estimates of potential marine mammal sonar exposures without consideration of standard mitigation and monitoring procedures. The caveats to interpretations of model results have been explained previously. It is highly unlikely that a marine mammal would experience any long-term effects because the large area of the TMAA makes individual mammals' repeated or prolonged exposures to high-level sonar signals unlikely. Specifically, MFA sonars have limited marine mammal high-level (TTS and PTS) exposure ranges and relatively high platform speeds. The number of exposures that exceed the PTS threshold and result in MMPA Level A harassment from sonar is one per year for Dall's porpoise. Therefore, long term effects on individuals, populations or stocks are unlikely.

When analyzing the results of the acoustic exposure modeling to provide an estimate of effects, it is important to understand that there are limitations to the ecological data (diving behavior, migration or movement patterns and population dynamics) used in the model, and that the model results must be interpreted within the context of a given species' ecology.

This authorization request assumes that short-term non-injurious MFA sonar sound exposure levels predicted to cause TTS and/or non-TTS behavioral disruptions qualify as MMPA Level B harassment. This approach is overestimating because there is no established scientific correlation between MFA sonar use and significant alteration of behavioral patterns in marine mammals.

In addition to the predicted exposure numbers or expected values resulting from acoustic modeling, there remains the possibility, although rare, that a marine mammal may be present in the TMAA when Navy activities are occurring (rare in this context refers to a species that is few in number in the GOA).

Table 6-7. Summary of Annual Sonar and Non-Sonar Acoustic Exposures from the Proposed Training Activities

Species	MMPA Level B Harassment		MMPA Level A Harassment
	Non-TTS	**TTS**	**PTS**
ESA Species			
Blue whale	1*	0	0
Fin whale	10,998	21	0
Humpback whale	1,388	6	0
North Pacific Right whale	1*	0	0
Sei whale	4*	0	0
Sperm whale	327	1	0
Steller sea lion	11,104	1	0
Non-ESA Listed Species			
Baird’s beaked whale	485	1	0
Cuvier’s beaked whale	2,302	6	0
Dall’s porpoise	205,485	768	1
Gray whale	384	1	0
Harbor Porpoise	5,438	0	0
Killer whale	10,602	41	0
Minke whale	677	2	0
Pacific white-sided dolphin	16,912	61	0
Stejneger’s beaked whale	2,302	6	0
California sea lion	1*	0	0
Harbor seal	1*	0	0
Northern elephant seal	2,064	0	0
Northern fur seal	154,144	16	0
Total	**424,620**	**931**	**1**

TTS and PTS Thresholds: Cetaceans TTS = 195 dB re 1 µPa^2-s; PTS = 215 dB, re 1 µPa^2-s; Northern elephant seal TTS = 204 re 1 µPa^2-s, PTS = 224 re 1 µPa^2-s; Otariids TTS = 206 re 1 µPa^2-s, PTS = 226 re 1 µPa^2-s; * = Accounting for rare animals.

Notes: ESA = Endangered Species Act, MMPA = Marine Mammal Protection Act, PTS = Permanent Threshold Shift, TTS = Temporary Threshold Shift

For some species whose numbers are few but have a known abundance (e.g., sperm whale, gray whale, minke whale), acoustic modeling was completed but the results indicate no predicted exposures for at-sea explosions under any alternative. For other species (blue whale, California sea lion, harbor porpoise, harbor seal, North Pacific Right whale, and sei whale), there are no valid abundance or density estimates for the TMAA. However, even if an accurate abundance or density could be derived for these species, being so few in number in the TMAA, accepted modeling methodology will predict zero exposures (based on modeling results for species with higher abundance such as sperm and gray whale, but having no predicted exposures). To account for the possibility that harassment of rare marine mammals may occur, special consideration has been given these cases. Therefore, for each proposed 21-day exercise period, the number of behavioral harassments per rare species will be based on an assumption of having exposed the species average group size to one instance of behavioral harassment to account for all at-sea explosions and one instance average group size behavioral harassment to account for all acoustic sources (e.g., sonar, pingers, EMATT) for purposes of this analysis in the TMAA. This use of average group size was only used if there was no data available for modeling or if modeling resulted in zero exposures for the species. Table 6-8 provides the average group size for rare species in the TMAA as derived or reported from the citations listed.

Table 6-8. Average Group Size for Rare Species in the TMAA.

Species	Average Group Size - Rounded[1]	Total Encounters (number of individuals)	Reference
ESA Listed Cetacea			
Blue whale	1	15(15)	Calambokidis et al., (2009)
North Pacific right whale	1	1(1)[2]	Angliss and Allen (2008)
Sei whale	4	-	Leatherwood et al., (1988)
Sperm whale	1[3]	-	Rone et al., (2009)
Non-ESA Listed Cetacea			
Gray whale	3	3(8)	Rone et al., (2009)
Harbor porpoise	2	30(89)	Rone et al., (2009)
Minke whale	2	2(3)	Rone et al., (2009)
Non-ESA Listed Pinniped			
California sea lion	1[4]	-	-
Harbor seal	1	2(2)	Rone et al., (2009)

1. Lacking otherwise published numbers for Average Group Size for marine mammals in the TMAA, the method for deriving Average Group Size for use in quantifying the potential for rare animals was to take survey data providing the total number of animals sighted and dividing that by the number of visual encounters for each species during that survey with the resulting number then rounded to a whole number.

2. Based on the sighting in GOA of one lone North Pacific right whale in with a group of humpbacks from Waite (2003).

3. Based on no sightings of family groups although numerous acoustic detections were made.

4. It is assumed given that California sea lions are very rare in GOA, that they would only be encountered individually even if a prey species was running.

Because of the time delay between pings, and platform speed, an animal encountering the sonar will accumulate energy for only a few sonar pings over the course of a few minutes. Therefore, exposure to sonar would be a short-term event, minimizing any single animal's exposure to sound levels approaching the harassment thresholds.

The implementation of the mitigation and monitoring procedures as addressed in Chapter 11 will further minimize the potential for marine mammal exposures to explosive sources. When reviewing the acoustic exposure modeling results, it is also important to understand that the estimates of marine mammal sound exposures are presented without consideration of standard protective measure operating procedures. Chapter 11 presents details of the mitigation measures currently used for ASW activities including detection of marine mammals and power down procedures if marine mammals are dectected within one of the safety zones. The Navy will work through the MMPA incidental harassment regulatory process to discuss the mitigation measures and their potential to reduce the likelihood for incidental harassment of marine mammals.

6.11.3 Summary of Potential At-Sea Explosion Effects

Training operations potentially resulting in at-sea explosions include BOMBEX, surface-to-surface GUNEX, and use of SSQ-110A sonobuoy (EER/IEER Systems) (see Table 6-9).

Potential exposures resulting from at-sea explosions are provided in Table 6-9. These exposure modeling results are estimates of marine mammal at-sea explosion sound exposures recognizing the same model limitations as discussed in the summary of MFA sonar sub-section (Section 6.5.2). In addition, implementation of the mitigation and monitoring procedures as addressed in Section 11.1 will minimize the potential for marine mammal exposures to at-sea explosions and reduce the number of actual exposures resulting from training activities.

Table 6-9. Summary Quantification of Bomb, HE Rounds, and SSQ-110A Sonobuoy Use Per Year Resulting in At-Sea Explosions from the Proposed Training Activities

Event	MK-82	MK-83	MK-84	76 mm	5 in	SSQ-110A IEER Sonobuoy
1st Summer Exercise	64	6	2	**14**	42	40
2nd Summer Exercise	64	6	2	**14**	42	40
Preferred Alternative (Total)	**128**	**12**	**40**	**28**	**84**	**80**

For at-sea explosives, the modeling indicates (per year) 163 MMPA Level B harassments from sub-TTS from multiple successive explosions; 70 MMPA Level B harassment from TTS; four MMPA Level A harassment from PTS exposures; and one exposure that could cause severe injury or mortality.

6.11.4 Estimated Effects on Endangered Species Act (ESA) Species

The endangered species that may be affected as a result of Navy training activities in the TMAA include the blue whale (*Balaenoptera musculus*), fin whale (*Balaenoptera physalus*), humpback whales (*Megaptera novaeangliae*), North Pacific right whale (*Eubalaena robustus*), sei whale (*Balaenoptera borealis*), sperm whale (*Physeter macrocephalus*), and Steller sea lion (*Eumetopias jubatus*).

6.11.4.1 Blue Whale

Accounting for the potential that rare species may be present and based on the estimated average group size of one derived from Calambokidis et al., (2009), this analysis accounts for the potential exposure of one blue whale to MMPA Level B harassment from non-TTS from activities using acoustic sources (e.g., sonar, pingers, etc., Table 6-7) and one MMPA Level B harassment from activities using at-sea explosives (Table 6-10). No blue whale would be exposed to any at-sea explosive or acoustic events that could cause MMPA Level A harassment in the TMAA.

An ESA consultation will be initiated, and will include the finding that the proposed exercises may affect blue whales. Should consultation under the ESA conclude that the estimated exposures of blue whales can be avoided using mitigation measures or that the received sound is not likely to adversely affect blue whale, authorization for these exposures would not be requested under MMPA. At this time, Navy requests authorization for the annual harassment of two blue whales by Level B harassment (one from sonar and one from at-sea explosions) and no blue whales by Level A harassment from potential exposure to sonar or at-sea explosions.

6.11.4.2 Fin Whale

The risk function and Navy post-modeling analysis estimates there would be 10,998 fin whale MMPA Level B harassments from non-TTS as estimated via the risk function methodology (Table 6-7). Modeling also indicates there would be 21 MMPA Level B harassments from TTS resulting from exposure to accumulated acoustic energy at or above 195 dB re 1 μPa^2-s. No fin whales would be exposed to sound levels that could cause MMPA Level A harassment from use of sonar in the TMAA.

Table 6-10. Annual At-Sea Explosion Exposures Summary for the Proposed Training Activities

Species	MMPA Level B Harassment		MMPA Level A Harassment	Mortality
	Sub-TTS 177dB dB re 1μPa^2-s (MSE)	TTS 182 dB / 23 psi	50 percent TM Rupture 205 dB Slight Lung Injury or 23 psi-ms	Onset massive Lung Injury or Mortality 31 psi-ms
ESA Species				
Blue whale	1*	0	0	0
Fin whale	13	5	0	0
Humpback whale	1	0	0	0
North Pacific Right whale	1*	0	0	0
Sei whale	4*	0	0	0
Sperm whale	1*	0	0	0
Steller sea lion	2	1	0	0
Non-ESA Listed Species				
Baird's beaked whale	1	0	0	0
Cuvier's beaked whale	3	1	0	0
Dall's porpoise	84	37	2	1
Gray whale	3*	0	0	0
Harbor Porpoise	2*	0	0	0
Killer whale	4	2	0	0
Minke whale	2*	0	0	0
Pacific white-sided dolphin	12	6	1	0
Stejnger's beaked whale	4	1	0	0
California sea lion	1*	0	0	0
Harbor Seal	1*	0	0	0
Northern elephant seal	4	1	0	0
Northern fur seal	26	16	1	0
Total	**170**	**70**	**4**	**1**

Notes: dB = decibel, dB re 1μPa2-s = decibels referenced to 1 micropascal squared per second, ESA = Endangered Species Act, MMPA = Marine Mammal Protection Act, MSE = Multiple Successive Explosions, psi = pound per square inch, psi-ms = pounds per square inch per millisecond, TM = Tympanic membrane, TTS = Temporary Threshold Shift; * = Accounting for rare animals.

Without consideration of clearance procedures, there would be 13 MMPA Level B harassments from sub-TTS resulting from exposure to accumulated acoustic energy at or above 177 dB re 1 μPa^2-s for MSE. There would be 5 MMPA Level B harassments from TTS as a result of at-sea explosions with exposures at or above 182 dB re 1 μPa^2-s or at 23 psi. There would be no MMPA Level A harassment and no predicted exposure that would exceed the mortality threshold (Table 6-10).

Given the large size (up to 78 ft [24m]) of individual fin whales (Leatherwood et al. 1982), pronounced vertical blow, mean aggregation of three animals in a group (probability of trackline detection = 0.90 in Beaufort Sea States of 6 or less; Barlow 2003) it is likely that lookouts would detect a group of fin whales at the surface. The implementation of mitigation measures to reduce exposure to high levels of sonar sound; and the short duration and intermittent exposure to sonar, reduces the likelihood that exposure to MFA/HFA sonar sound would cause a behavioral response that may affect vital functions (reproduction or survival), TTS or PTS.

In the St. Lawrence estuary area, fin whales avoided vessels with small changes in travel direction, speed and dive duration, and slow approaches by boats usually caused little response (MacFarlane, 1981). Fin whales continued to vocalize in the presence of boat sound (Edds and Macfarlane 1987). Even though any undetected fin whales transiting the TMAA may exhibit a reaction when initially exposed to active acoustic energy, field observations indicate the effects would not cause disruption of natural behavioral patterns to a point where such behavioral patterns would be abandoned or significantly altered.

Target area clearance procedures, which are part of the Navy's standard mitigation measures, reduce the likelihood that fin whales will be exposed to at sea explosions associated with Navy training events. The set up procedures and checks required for safety of event participants make it unlikely fin whales would remain in an area undetected before explosive detonation occurred.

Based on the model results, behavioral patterns, acoustic abilities of fin whales, results of past training, and the implementation of procedure mitigation measures presented in Section 11.1 for sonar and Section 11.2 for at-sea explosions, the Navy finds that the GOA training events may affect fin whales. It is unlikely that GOA training activities would result in any death or injury to fin whales. Modeling does indicate the potential for MMPA Level B harassment, indicating the proposed ASW exercises may affect fin whales but are not likely to cause long-term effects on their behavior or physiology or abandonment of areas that are regularly used by fin whales.

An ESA consultation will be initiated, and will include the finding that the proposed ASW exercises may affect fin whales. Should consultation under the ESA conclude that the estimated exposures of fin whales can be avoided using mitigation measures or that the received sound is not likely to adversely affect fin whales, authorization for the predicted exposures would not be requested under MMPA. At this time, Navy requests authorization for the annual harassment of 11,037 fin whales by MMPA Level B harassment (11,019 from sonar and 18 from at-sea explosions) and no fin whales by MMPA Level A harassment from potential exposure to sonar or at-sea explosions.

6.11.4.3 Humpback Whale

The risk function and Navy post-modeling analysis estimates there would be 1,388 humpback whale MMPA Level B harassments from non-TTS as estimated via the risk function methodology (Table 6-7). Modeling also indicates there would be 6 MMPA Level B harassments from TTS resulting from exposure to accumulated acoustic energy at or above 195 dB re 1 μPa^2-s. No humpback whales would be exposed to sound levels that could cause MMPA Level A harassment from use of sonar in the TMAA.

Without consideration of clearance procedures, there would be one humpback whale MMPA Level B harassments from sub-TTS resulting from exposure to accumulated acoustic energy at or above 177 dB re 1 μPa^2-s for MSE. There would be no MMPA Level B harassments from TTS as a result of at-sea explosions with exposures at or above 182 dB re 1 μPa^2-s or at 23 psi. There would be no MMPA Level A harassment and no predicted exposure that would exceed the mortality threshold (Table 6-10).

Given the large size (up to 53 ft [16m]) of individual humpback whales (Leatherwood et al. 1982), and pronounced vertical blow, it is likely that lookouts would detect humpback whales at the surface. The implementation of mitigation measures to reduce exposure to high levels of sonar sound; and the short duration and intermittent exposure to sonar, reduces the likelihood that exposure to sonar sound would cause a behavioral response that may affect vital functions (reproduction or survival), TTS, or PTS.

There are no audiograms of baleen whales, but they tend to react to anthropogenic sound below 1 kHz, suggesting that they are more sensitive to low-frequency sounds (Richardson et al. 1995). Based on this information, if they do not hear these sounds, they are not likely to respond physiologically or behaviorally to those received levels, such that effects would be insignificant. A single study suggested that humpback whales responded to mid-frequency sonar (3.1-3.6 kHz re 1 μPa^2-s) sound (Maybaum 1989). The hand held sonar system had a sound artifact below 1,000 Hz which caused a response to the control playback (a blank tape) and may have affected the response to sonar (i.e., the humpback whale responded to the low-frequency artifact rather than the MFA sonar sound). Humpback whales responded to small vessels (often whale watching boats) by changing swim speed, respiratory rates and social interactions depending on proximity to the vessel and vessel speed, with responses varying by social status and gender (Watkins et al. 1981, Bauer 1986, Bauer and Herman 1986). Animals may even move out of the area in response to vessel noise (Salden 1988). Frankel and Clark (2000; 2002) reported that there was only a minor response by humpback whales to the Acoustic Thermometry of Ocean Climate sound source and that response was variable with some animals being found closer to the sound source during use.

Target area clearance procedures, which are part of the Navy's standard mitigation measures, reduce the likelihood that humpback whales will be exposed to at-sea explosions associated with Navy training events. The set up procedures and checks required for safety of event participants make it unlikely humpback whales would remain in an area undetected before explosive detonation occurred.

Based on the model results, behavioral patterns, acoustic abilities of humpback whales, results of past training, and the implementation of procedure mitigation measures presented in Section 11.1 for sonar and Section 11.2 for at-sea explosions, the Navy finds that the GOA training events may affect humpback whales. It is unlikely that GOA training activities would result in any death or injury to humpback whales. Modeling does indicate the potential for Level B harassment, indicating the proposed ASW exercises may affect humpback whales but are not likely to cause long-term effects on their behavior or physiology or abandonment of areas that are regularly used by humpback whales.

An ESA consultation will be initiated, and will include the finding that the proposed ASW exercises may affect humpback whales. Should consultation under the ESA conclude that the estimated exposures of humpback whales can be avoided using mitigation measures or that the received sound is not likely to adversely affect humpback whales, authorization for the predicted exposures would not be requested under MMPA. At this time, Navy requests authorization for the annual harassment of 1,394 humpback whales by Level B harassment (1,388 from sonar and one from at-sea explosions) and no humpback whales by Level A harassment from potential exposure to sonar or at-sea explosions.

6.11.4.4 North Pacific right whale

Accounting for the potential that rare species may be present and based on the estimated average group size of one, this analysis accounts for the potential exposure of one right whale to MMPA Level B harassment from non-TTS from activities using acoustic sources (e.g., sonar, pingers, etc., Table 6-7) and one MMPA Level B harassment resulting from activities using at-sea explosives (Table 6-10). No right whale would be exposed to any at-sea explosive or acoustic events that could cause MMPA Level A harassment in the TMAA.

An ESA consultation will be initiated, and will include the finding that the proposed exercises may affect right whales. Should consultation under the ESA conclude that the estimated exposures of right whales can be avoided using mitigation measures or that the received sound is not likely to adversely affect right whale, authorization for these exposures would not be requested under MMPA. At this time, Navy requests authorization for the annual harassment of two right whales by Level B harassment (one from sonar and one from at-sea explosions) and no right whales by Level A harassment from potential exposure to sonar or at-sea explosions.

6.11.4.5 Sei Whale

Accounting for the potential that rare species may be present and based on the average group size of four presented by Leatherwood et al., (1988) this analysis accounts for the potential exposure of four sei whales to MMPA Level B harassments from non-TTS from activities using acoustic sources (e.g., sonar, pingers, etc., Table 6-7) and four MMPA Level B harassments resulting from activities using at-sea explosives (Table 6-10). No sei whale would be exposed to any at-sea explosive or acoustic events that could cause MMPA Level A harassment in the TMAA.

An ESA consultation will be initiated, and will include the finding that the proposed exercises may affect sei whales. Should consultation under the ESA conclude that the estimated exposures of sei whales can be avoided using mitigation measures or that the received sound is not likely to adversely affect sei whales, authorization for these exposures would not be requested under MMPA. At this time, Navy requests authorization for the annual harassment of eight sei whales by Level B harassment (four from sonar and four from at-sea explosions) and no sei whales by Level A harassment from potential exposure to sonar or at-sea explosions.

6.11.4.6 Sperm Whale

The risk function and Navy post-modeling analysis estimates there would be 327 sperm whale MMPA Level B harassments from non-TTS as estimated via the risk function methodology (Table 6-7). Modeling indicates there would be one MMPA Level B harassment from TTS resulting from exposure to accumulated acoustic energy at or above 195 dB re 1 μPa^2-s. No sperm whale would be exposed to sound levels that could cause MMPA Level A harassment from use of sonar in the TMAA.

Accounting for the potential that rare species may be present and based on the average group size of one derived from Rone et al., (2009), there would be one sperm whale MMPA Level B harassment resulting from activities using at-sea explosives. There would be no MMPA Level B harassments from TTS as a result of at-sea explosions with exposures at or above 182 dB re 1 μPa^2-s or at 23 psi, none that would exceed the MMPA Level A harassment onset of slight injury threshold, and no exposure that would exceed the onset of extensive lung injury or the mortality threshold (Table 6-10).

Given the large size (up to 56 ft [17m]) of individual sperm whales (Leatherwood et al. 1982), pronounced blow (large and angled), mean group size of approximately seven animals (probability of trackline detection = 0.87 in Beaufort Sea States of 6 or less; Barlow 2003, 2006), it is likely that lookouts would detect a group of sperm whales at the surface. Sperm whales can make prolonged dives of up to two hours making detection more difficult but passive acoustic monitoring can detect sperm whales from their calls (Watwood et al. 2006). The implementation of mitigation measures to reduce exposure to high levels of sonar sound; and the short duration and intermittent exposure to sonar, reduces the likelihood that exposure to MFA/HFA sonar sound would cause a behavioral response that may affect vital functions (reproduction or survival), TTS, or PTS.

In the unlikely event that sperm whales are exposed to mid-frequency sonar, the information available on sperm whales exposed to received levels of active mid-frequency sonar suggests that the response to mid-frequency (1 kHz to 10 kHz) sounds is variable (Richardson et al. 1995). While Watkins et al. (1985) observed that sperm whales exposed to 3.25 kHz to 8.4 kHz pulses interrupted their activities and left the area, other studies indicate that, after an initial disturbance, the animals return to their previous activity. During playback experiments off the Canary Islands, André et al. (1997) reported that foraging sperm whales exposed to a 10 kHz pulsed signal did not exhibit any general avoidance reactions. When resting at the surface in a compact group, sperm whales initially reacted strongly but then ignored the signal completely (André et al. 1997).

Target area clearance procedures, which are part of the Navy's standard mitigation measures, reduce the likelihood that sperm whales will be exposed to at sea explosions associated with Navy training events. The set up procedures and checks required for safety of event participants make it unlikely sperm whales would remain in an area undetected before explosive detonation occurred.

Based on the model results, behavioral patterns, acoustic abilities of sperm whales, results of past training, and the implementation of procedure mitigation measures presented in Section 11.1 for sonar and Section 11.2 for at-sea explosions, the Navy finds that the GOA training events may affect sperm whales. It is unlikely that GOA training activities would result in any death or injury to sperm whales. Modeling does indicate the potential for MMPA Level B harassment, indicating the proposed ASW exercises may affect sperm whales but are not likely to cause long-term effects on their behavior or physiology or abandonment of areas that are regularly used by sperm whales.

An ESA consultation will be initiated, and will include the finding that the proposed ASW exercises may affect sperm whales. Should consultation under the ESA conclude that the estimated exposures of sperm whales can be avoided using mitigation measures or that the received sound is not likely to adversely affect sperm whales, authorization for the predicted exposures would not be requested under MMPA. At this time, Navy requests authorization for the annual harassment of 329 sperm whales by MMPA Level B harassment (328 from sonar and one from at-sea explosions) and no sperm whales by MMPA Level A harassment from potential exposure to sonar or at-sea explosions.

6.11.4.7 Steller Sea Lion

The risk function and Navy post-modeling analysis estimates there would be 11,104 Steller sea lion MMPA Level B harassments from non-TTS as estimated via the risk function methodology (Table 6-7). Modeling also indicates there would be one MMPA Level B harassment from TTS resulting from exposure to accumulated acoustic energy at or above 206 dB re 1 μPa^2-s. No Steller sea lions would be exposed to sound levels that could cause MMPA Level A harassment from use of sonar in the TMAA.

Without consideration of clearance procedures, there would be two Steller sea lion MMPA Level B harassments from sub-TTS resulting from exposure to accumulated acoustic energy at or above 177 dB re 1 μPa^2-s for MSE. There would be one MMPA Level B harassment from TTS as a result of at-sea explosions with exposures at or above 182 dB re 1 μPa^2-s or at 23 psi. There would be no MMPA Level A harassment and no predicted exposure that would exceed the mortality threshold (Table 6-10).

Navy mitigation measures require continuous visual observation during activities with active sonar. Pinnipeds in the area may, therefore, be detected by Navy lookouts reducing the likelihood of exposure to high levels of sonar. The short duration and intermittent transmission of the sonar signal combined with relatively rapid vessel speed, reduces the likelihood that exposure to sonar sound would cause a behavioral response that may affect vital functions (reproduction or survival), TTS, or PTS.

Target area clearance procedures, which are part of the Navy's standard mitigation measures, reduce the likelihood that Steller sea lions will be exposed to at sea explosions associated with Navy training events. The set up procedures and checks required for safety of event participants make it unlikely Steller sea lions would remain in an area undetected before explosive detonation occurred.

Based on the model results, behavioral patterns, acoustic abilities of Steller sea lions, results of past training, and the implementation of procedure mitigation measures presented in Section 11.1 for sonar and Section 11.2 for at-sea explosions, the Navy finds that the GOA training events may affect steller sea lions. It is unlikely that GOA training activities would result in any death or injury to Steller sea lions. Modeling does indicate the potential for MMPA Level B harassment, indicating the proposed ASW exercises may affect Steller sea lions but are not likely to cause long-term effects on their behavior or physiology or abandonment of areas that are regularly used by Steller sea lions.

An ESA consultation will be initiated, and will include the finding that the proposed ASW exercises may affect Steller sea lions. Should consultation under the ESA conclude that the estimated exposures of Steller sea lions can be avoided using mitigation measures or that the received sound is not likely to adversely affect Steller sea lions, authorization for the predicted exposures would not be requested under MMPA. At this time, Navy requests authorization for the annual harassment of 11,108 Steller sea lions by MMPA Level B harassment (11,105 from sonar and three from at-sea explosions) and no Steller sea lions by MMPA Level A harassment from potential exposure to sonar or at-sea explosions.

6.11.5 Non-ESA Listed Marine Mammal Species

6.11.5.1 Baird's Beaked Whale

The risk function and Navy post-modeling analysis estimates there would be 485 Baird's beaked whale MMPA Level B harassments from non-TTS as estimated via the risk function methodology (Table 6-7). Modeling also indicates there would be one MMPA Level B harassment from TTS resulting from exposure to accumulated acoustic energy at or above 195 dB re 1 μPa^2-s. No Baird's beaked whale would be exposed to sound levels that could cause MMPA Level A harassment from use of sonar in the TMAA.

Without consideration of clearance procedures, there would be one Baird's beaked whale MMPA Level B harassment from sub-TTS resulting from exposure to accumulated acoustic energy at or above 177 dB re 1 μPa^2-s for MSE. For at-sea explosives, there would be no MMPA Level B harassment from TTS, no MMPA Level A harassment or exposures that would exceed the onset of slight injury threshold, and no exposure that would exceed the onset of extensive lung injury or the mortality threshold (Table 6-10).

Given the size (up to 15.5 ft. [4.7 m]) of individual Baird's beaked whales, aggregation of 2.3 animals, it is likely that lookouts may detect a group of Baird's beaked whales at the surface although beaked whales make prolonged dives that can last up to an hour (Baird et al. 2004). The implementation of mitigation measures to reduce exposure to high levels of sonar sound, and the short duration and intermittent exposure to sonar, reduces the likelihood that exposure to sonar sound would cause a behavioral response that may affect vital functions (reproduction or survival), TTS, or PTS.

Target area clearance procedures, which are part of the Navy's standard mitigation measures, reduce the likelihood that Baird's beaked whales will be exposed to at sea explosions associated with Navy training events. The set up procedures and checks required for safety of event participants make it unlikely Baird's beaked whales would remain in an area undetected before explosive detonation occurred.

At this time, Navy requests authorization for the annual harassment of 487 Baird's beaked whales by MMPA Level B harassment (486 from sonar and one from at-sea explosions) and no Baird's beaked whales by MMPA Level A harassment from potential exposure to sonar or at-sea explosions. Based on the model results, the nature of the Navy's sonar, behavioral patterns, observations made during past training events, and the planned implementation of mitigation (Section 11.1 for sonar and Section 11.2 for at-sea explosions) measures, the Navy finds that the GOA training events would not result in any population level effects, death or injury to Baird's beaked whales.

6.11.5.2 California Sea Lion

Accounting for the potential that rare species may be present and based on the estimated average group of one, this analysis accounts for the potential exposure of four California sea lions to MMPA Level B harassments from non-TTS from activities using acoustic sources (e.g., sonar, pingers, etc., Table 6-7) and one MMPA Level B harassments from activities using at-sea explosives (Table 6-10).

No California sea lion would be exposed to any at-sea explosive or acoustic events that could cause MMPA Level A harassment in the TMAA. At this time, Navy requests authorization for the annual harassment of two California sea lion by Level B harassment (one from sonar and one from at-sea explosions) and no California sea lion by Level A harassment from potential exposure to sonar or at-sea explosions.

6.11.5.3 Cuvier's Beaked Whale

The risk function and Navy post-modeling analysis estimates there would be 2,302 Cuvier's beaked whale MMPA Level B harassments from non-TTS as estimated via the risk function methodology (Table 6-7). Modeling also indicates there would be six MMPA Level B harassments from TTS resulting from exposure to accumulated acoustic energy at or above 195 dB re 1 μPa^2-s. No Cuvier's beaked whale would be exposed to sound levels that could cause MMPA Level A harassment from use of sonar in the TMAA.

Without consideration of clearance procedures, there would be three Cuvier's beaked whale MMPA Level B harassments from sub-TTS resulting from exposure to accumulated acoustic energy at or above 177 dB re 1 μPa^2-s for MSE. There would be one MMPA Level B harassment from TTS as a result of at-sea explosions with exposures at or above 182 dB re 1 μPa^2-s or at 23 psi. There would be no MMPA Level A harassment and no predicted exposure that would exceed the mortality threshold (Table 6-10).

Given the medium size (up to 23 ft. [7.0 m]) of individual Cuvier's beaked whales, aggregation of approximately two animals (Barlow, 2006), lookouts may detect a group of Cuvier's beaked whales at the surface although beaked whales make prolonged dives that can last up to an hour (Baird et al., 2004). The implementation of mitigation measures to reduce exposure to high levels of sonar sound, and the short duration and intermittent exposure to sonar, reduces the likelihood that exposure to sonar sound would cause a behavioral response that may affect vital functions (reproduction or survival), TTS, or PTS.

Target area clearance procedures, which are part of the Navy's standard mitigation measures, reduce the likelihood that Cuvier's beaked whales will be exposed to at sea explosions associated with Navy training events. The set up procedures and checks required for safety of event participants make it unlikely Cuvier's beaked whales would remain in an area undetected before explosive detonation occurred.

At this time, Navy requests authorization for the annual harassment of 2,312 Cuvier's beaked whales by MMPA Level B harassment (2,308 from sonar and four from at-sea explosions) and no Cuvier's beaked whales by MMPA Level A harassment from potential exposure to sonar or at-sea explosions. Based on the model results, the nature of the Navy's sonar, behavioral patterns and acoustic abilities of Cuvier's beaked whales, observations made during past training events, and the planned implementation of mitigation (Section 11.1 for sonar and Section 11.2 for at-sea explosions) measures, the Navy finds that the GOA training events would not result in any population level effects, death or injury to Cuvier's beaked whales.

6.11.5.4 Dall's Porpoise

The risk function and Navy post-modeling analysis estimates there would be 205,485 Dall's porpoise MMPA Level B harassments from non-TTS as estimated via the risk function methodology (Table 6-7).

Modeling also indicates there would be 768 MMPA Level B harassments from TTS resulting from exposure to accumulated acoustic energy at or above 195 dB re 1 μPa^2-s. One Dall's porpoise could be exposed to accumulated acoustic energy above 215 dB re 1 μPa^2-s that could result in MMPA Level A harassment from PTS. The distance required from the ship's SQS-53 sonar dome to a Dall's porpoise to have a received level exposure from a sonar ping in excess of the PTS threshold is approximately 33 ft (10 m) in the TMAA. Given the short distance required and the average group size of a pod resulting in a generally high visibility for Dall's porpoise, it is unlikely that this Level A exposure would occur.

Without consideration of clearance procedures, there would be 84 Dall's porpoise MMPA Level B harassments from sub-TTS resulting from exposure to accumulated acoustic energy at or above 177 dB re 1 μPa^2-s for MSE. There would be 37 MMPA Level B harassments from TTS as a result of at-sea explosions with exposures at or above 182 dB re 1 μPa^2-s or at 23 psi. Modeling estimates there would be two MMPA Level A harassments from the onset of slight injury as a result of exposure at 205 dB re 1 μPa^2-s or 13 psi-ms. Modeling also estimates one exposure that would exceed the onset of extensive lung injury or mortality threshold at 30.5 psi-ms (Table 6-10).

Given the frequent surfacing and aggregation of approximately 2-20 animals, it is very likely that lookouts would detect a group of Dall's porpoises at the surface. The implementation of mitigation measures to reduce exposure to high levels of sonar sound, and the short duration and intermittent exposure to sonar, reduces the likelihood that exposure to sonar sound would cause a behavioral response that may affect vital functions (reproduction or survival), TTS, or PTS.

The Navy's proposed mitigation has a provision that allows the Navy to continue operation of sonar if the animals are clearly bow-riding even after the Navy has initially maneuvered to try and avoid closing with the animals. Since these animals sometimes bow-ride and could potentially be exposed to levels associated with harassment as they approach or depart from bow-riding, it is estimated that half or less of the number of Dall's porpoise modeled would sustain harassment. (National Oceanic and Atmospheric Administration, 2008b)

Target area clearance procedures, which are part of the Navy's standard mitigation measures, reduce the likelihood that Dall's porpoise will be exposed to at sea explosions associated with Navy training events. The set up procedures and checks required for safety of event participants make it unlikely Dall's porpoise would remain in an area undetected before explosive detonation occurred. For these reasons, it is unlikely that any MMPA Level A harassment exposures to Dall's porpoise would occur as a result of training activities involving at-sea explosions.

At this time, Navy requests authorization for the annual harassment of 206,374 Dall's porpoises by MMPA Level B harassment (206,253 from sonar and 121 from at-sea explosions), three by MMPA Level A harassment from potential exposure to sound associated with an at-sea explosion, and one resulting in mortality to Dall's porpoise. Based on the model results, the nature of the Navy's sonar, behavioral patterns and acoustic abilities of Dall's porpoises, observations made during past training events, and the planned implementation of mitigation (Section 11.1 for sonar and Section 11.2 for at-sea explosions) measures, the Navy finds that the GOA training events would not result in any population level effects to Dall's porpoises.

6.11.5.5 Gray Whale

The risk function, accounting for rare species, and Navy post-modeling analysis estimates there would be 384 gray whale MMPA Level B harassments from non-TTS as estimated via the risk function methodology (Table 6-7). Modeling also indicates there would be one MMPA Level B harassment from TTS resulting from exposure to accumulated acoustic energy at or above 195 dB re 1 μPa^2-s. No gray whale would be exposed to sound levels that could cause MMPA Level A harassment from use of sonar in the TMAA.

Accounting for the potential that rare species may be present and based on the average group size of three derived from Rone et al., (2009), there would be three gray whale MMPA Level B harassments resulting from activities using at-sea explosives. There would be no MMPA Level B harassments from TTS as a result of at-sea explosions with exposures at or above 182 dB re 1 μPa^2-s or at 23 psi. There would be no MMPA Level A harassment and no predicted exposure that would exceed the mortality threshold (Table 6-10).

Given the large size (up to 49 ft [15 m]) of individual gray whales, pronounced vertical blow, and mean aggregation of three animals in a group, it is likely that lookouts would detect a group of gray whales at the surface. The implementation of mitigation measures to reduce exposure to high levels of sonar sound and the short duration and intermittent exposure to sonar, reduces the likelihood that exposure to sonar sound would cause a behavioral response that may affect vital functions (reproduction or survival), TTS or PTS.

Target area clearance procedures, which are part of the Navy's standard mitigation measures, reduce the likelihood that gray whales will be exposed to at sea explosions associated with Navy training events. The set up procedures and checks required for safety of event participants make it unlikely gray whales would remain in an area undetected before explosive detonation occurred.

At this time, Navy requests authorization for the annual harassment of 388 gray whales by MMPA Level B harassment (385 from sonar and three from at-sea explosions) and no gray whales by MMPA Level A harassment from potential exposure to sonar or at-sea explosions. Based on the model results, the nature of the Navy's sonar, behavioral patterns and acoustic abilities of gray whales, observations made during past training events, and the planned implementation of mitigation measures (Section 11.1 for sonar and Section 11.2 for at-sea explosions), the Navy finds that the GOA training events would not result in any population level effects, death or injury to gray whales.

6.11.5.6 Harbor Porpoise

Harbor porpoise in Alaska waters are clustered in nearshore waters, bays, and inlets. Annual aerial surveys from 1991 to 1993 had only two sightings within 16 nm (30 km) of shore (Dahlheim et al. 2000) and a more recent survey to the shelf break (approximately 150 to 200 km from shore; Waite 2003) had only one sighting. They occur in most frequently waters less than 328 ft (100 m) in depth (Angliss and Outlaw 2007). Based on these findings and general known habitat preference, harbor porpoise are not likely to be within the nearshore fraction of the TMAA given the boundary is 44 km (24 nm) from Kenai Peninsula. As a result, there is insufficient data for harbor porpoise in the GOA stock from which a standard estimated density (e.g., Barlow, 2003) could be derived for input into acoustic modeling. Given, however, that special consideration has been made for harbor porpoise by establishment of a separate step function threshold at 120 dB SPL to estimate the number of harbor porpoise that will respond in a manner the NMFS considers behavioral harassment under MMPA, an alternative method to estimate the potential number of non-TTS exposures is required. This is because the 120 dB SPL threshold is so low (in many cases at or below ambient noise conditions in nearshore waters), that virtually any anthropogenic sound perceived by harbor porpoise exceeds this MMPA Level B regulatory threshold. As a result, the few harbor porpoise that may be in the TMAA would potentially be exposed to a sound level considered by NMFS to be behavioral harassment under MMPA for military readiness activities even though the sound source related to that exposure may be up to 57 nm (105 km) radius from that received level in the GOA.

To derive an estimate for the number of harbor porpoise that may be exposed to potential MMPA Level B harassment from non-TTS, an analysis of the approximate distribution of harbor porpoise in the GOA stock (occurring from Unimak Pass to Cape Suckling as presented in the stock assessment; Angliss and Outlaw, 2007) was undertaken as a first step. The stock assessment information indicates an area for the GOA stock of approximately 69,829 nm^2 (239,597 km^2) with an abundance of 41,854 animals, resulting in the second highest density for a marine mammal species in the GOA (0.5993/nm^2 or 0.1747/km^2). The nearshore portion of the TMAA overlaps this approximate distribution by an area of 4,538 nm^2 (15,565 km^2). If an even distribution of harbor porpoise in the GOA stock is assumed, there would be 2,719 harbor porpoise in the portion of the TMAA that overlaps the distribution as presented in the stock assessment. While this is likely an overestimate for the number of animals present in the area given the TMAA is outside harbor porpoise habitat preferences, it will be assumed for purposes of this analysis that 2,719 harbor porpoise would be exposed to a sound level at or above 120 dB SPL resulting in MMPA Level B behavioral harassment from non-TTS during each proposed summer training event. Furthermore, the MMPA Level B harassment threshold for harbor porpoise presupposes a significant non-TTS behavioral reaction will occur at distances tens of miles from the source. NMFS believes it is likely that many animals will avoid sonar sources to some degree (National Oceanic and Atmospheric Administration 2008b). Thus behavioral reactions at this distance should preclude exposures to other, higher sound level thresholds (TTS, PTS, or direct injury) given the distance for TTS from a surface ship sonar with a 235 dB re 1µ Pa @ 1m source level, is approximately 548 ft (178 meters). There should, therefore, be no exposures from sonar to harbor porpoise resulting in TTS, PTS, or injury.

Given harbor porpoise general avoidance of anthropogenic activity and that the nearshore portion of the TMAA is not a likely location for activities involving at-sea explosions. However, based on the accounting for the potential that rare species may be present and based on the average group size of two derived from Rone et al., (2009), there would be two exposures to harbor porpoise resulting in MMPA Level B harassment resulting from activities using at-sea explosives (Table 6-10). There should be no exposures resulting in MMPA Level A from PTS or injury as a result of sound or pressure associated with at-sea explosions. Therefore, as shown on Table 6-7 and 6-10, there would be a total of 5,440 harbor porpoise MMPA Level B harassments from non-TTS for purposes of this authorization request.

6.11.5.7 Harbor Seal

Accounting for the potential that rare species may be present and based on the average group size of one derived from Rone et al., (2009), this analysis accounts for the potential exposure of one harbor seal to MMPA Level B harassment from non-TTS from activities using acoustic sources (e.g., sonar, pingers, etc., Table 6-7) and one MMPA Level B harassment resulting from activities using at-sea explosives (Table 6-10). No harbor seal would be exposed to any at-sea explosive or acoustic events that could cause MMPA Level A harassment in the TMAA. At this time, Navy requests authorization for the annual harassment of two harbor seal by Level B harassment (one from sonar and one from at-sea explosions) and no harbor seal by Level A harassment from potential exposure to sonar or at-sea explosions.

6.11.5.8 Killer Whale (Resident, Offshore, and Transient)

Modeling for killer whale in the TMAA assumed a single density based on the observed number of resident killer whale in the survey area closest to the TMAA. The risk function and Navy post-modeling analysis estimates there would be 10,602 killer whale MMPA Level B harassments from non-TTS as estimated via the risk function methodology (Table 6-7). Modeling also indicates there would be 41 MMPA Level B harassments from TTS resulting from exposure to accumulated acoustic energy at or above 195 dB re 1 μPa^2-s. No killer whale would be exposed to sound levels that could cause MMPA Level A harassment from use of sonar in the TMAA.

Without consideration of clearance procedures, there would be four killer whale MMPA Level B harassments from sub-TTS resulting from exposure to accumulated acoustic energy at or above 177 dB re 1 μPa^2-s for MSE. Modeling estimates two MMPA Level B harassments from TTS as a result of at-sea explosions with exposures at or above 182 dB re 1 µPa^2-s or at 23 psi. There would be no MMPA Level A harassment and no predicted exposure that would exceed the mortality threshold (Table 6-10).

Given their size (up to 23 ft [7.0 m]), conspicuous coloring, pronounce dorsal fin and large mean group size of 6.5 animals (probability of trackline detection = 0.90 in Beaufort Sea States of 6 or less; Barlow, 2003). It is very likely that lookouts would detect a group of killer whales at the surface. The implementation of mitigation measures to reduce exposure to high levels of sonar sound, and the short duration and intermittent exposure to sonar, reduces the likelihood that exposure to sonar sound would cause a behavioral response that may affect vital functions (reproduction or survival), TTS, or PTS.

Target area clearance procedures, which are part of the Navy's standard mitigation measures, reduce the likelihood that killer whales will be exposed to at sea explosions associated with Navy training events. The set up procedures and checks required for safety of event participants make it unlikely killer whales would remain in an area undetected before explosive detonation occurred.

At this time, Navy requests authorization for the annual harassment of 10,608 killer whales by MMPA Level B harassment (10,602 from sonar and six from at-sea explosions) and no killer whales by MMPA Level A harassment from potential exposure to sonar or at-sea explosions. Based on the model results, the nature of the Navy's sonar, behavioral patterns and acoustic abilities of killer whales, observations made during past training events, and the planned implementation of mitigation (Section 11.1 for sonar and Section 11.2 for at-sea explosions) measures, the Navy finds that the GOA training events would not result in any population level effects, death or injury to killer whale.

6.11.5.9 Minke Whale

The risk function and Navy post-modeling analysis estimates there would be 677 minke whale MMPA Level B harassments from non-TTS as estimated via the risk function methodology (Table 6-7). Modeling also indicates there would be two MMPA Level B harassments from TTS resulting from exposure to accumulated acoustic energy at or above 195 dB re 1 µPa^2-s. No minke whale would be exposed to sound levels that could cause PTS and result in MMPA Level A harassment exposures.

Accounting for the potential that rare species may be present and based on the average group size of two derived from Rone et al., (2009), this analysis accounts for the potential exposure of two minke whale to MMPA Level B harassments resulting from activities using at-sea explosives. There would be no MMPA Level B harassments from TTS as a result of at-sea explosions with exposures at or above 182 dB re 1 µPa^2-s or at 23 psi. There would be no MMPA Level A harassment and no predicted exposure that would exceed the mortality threshold (Table 6-10).

Minke whales are difficult to spot visually but can be detected using passive acoustic monitoring. The implementation of mitigation measures to reduce exposure to high levels of sonar sound; and the short duration and intermittent exposure to sonar, reduces the likelihood that exposure to sonar sound would cause a behavioral response that may affect vital functions (reproduction or survival), TTS, or PTS.

Target area clearance procedures, which are part of the Navy's standard mitigation measures, reduce the likelihood that minke whales will be exposed to at sea explosions associated with Navy training events. The set up procedures and checks required for safety of event participants make it unlikely minke whales would remain in an area undetected before explosive detonation occurred.

At this time, Navy requests authorization for the annual harassment of 681 minke whales by MMPA Level B harassment (679 from sonar and two from at-sea explosions) and no minke whales by MMPA Level A harassment from potential exposure to sonar or at-sea explosions. Based on the model results, the nature of the Navy's sonar, behavioral patterns and acoustic abilities of minke whales, observations made during past training events, and the planned implementation of mitigation (Section 11.1 for sonar and Section 11.2 for at-sea explosions) measures, the Navy finds that the GOA training events would not result in any population level effects, death or injury to minke whales.

6.11.5.10 Pacific White-Sided Dolphin

The risk function and Navy post-modeling analysis estimates there would be 16,912 Pacific white-sided dolphin MMPA Level B harassments from non-TTS as estimated via the risk function methodology (Table 6-7). Modeling also indicates there would be 61 MMPA Level B harassments from TTS resulting from exposure to accumulated acoustic energy at or above 195 dB re 1 μPa^2-s. No Pacific white-sided dolphin would be exposed to sound levels that could cause MMPA Level A harassment from use of sonar in the TMAA.

Without consideration of clearance procedures, there would be 12 MMPA Level B harassment from sub-TTS resulting from exposure to accumulated acoustic energy at or above 177 dB re 1 μPa^2-s for MSE. There would be six MMPA Level B harassments from TTS as a result of at-sea explosions with exposures at or above 182 dB re 1 μPa^2-s or at 23 psi. There would be no MMPA Level A harassment and no predicted exposure that would exceed the mortality threshold (Table 6-10).

Given the frequent surfacing and aggregation of approximately 2-20 animals, it is very likely that lookouts would detect a group of Pacific white-sided dolphin at the surface. The implementation of mitigation measures to reduce exposure to high levels of sonar sound, and the short duration and intermittent exposure to sonar, reduces the likelihood that exposure to MFA/HFA sonar sound would cause a behavioral response that may affect vital functions (reproduction or survival), TTS, or PTS.

The Navy's proposed mitigation has a provision that allows the Navy to continue operation of sonar if the animals are clearly bow-riding even after the Navy has initially maneuvered to try and avoid closing with the animals. Since Pacific white-sided dolphin sometimes bow-ride and could potentially be exposed to levels associated with harassment as they approach or depart from bow-riding, it is estimated that half or less of the number of Pacific white-sided dolphin modeled would sustain harassment. (National Oceanic and Atmospheric Administration 2008b)

Target area clearance procedures, which are part of the Navy's standard mitigation measures, reduce the likelihood that Pacific white-sided dolphin will be exposed to at sea explosions associated with Navy training events. The set up procedures and checks required for safety of event participants make it unlikely Pacific white-sided dolphin would remain in an area undetected before explosive detonation occurred. For these reasons, it is unlikely that any MMPA Level A harassment exposures to Pacific white-sided dolphin would occur as a result of training activities involving at-sea explosions.

At this time, Navy requests authorization for the annual harassment of 16,991 Pacific white-sided dolphin by MMPA Level B harassment (16,973 from sonar and 18 from at-sea explosions) from potential exposure to sonar or at-sea explosions. Based on the model results, the nature of the Navy's sonar, behavioral patterns and acoustic abilities of Pacific white-sided dolphin, observations made during past training events, and the planned implementation of mitigation measures (Section 11.1 for sonar and Section 11.2 for at-sea explosions), the Navy finds that the GOA training events would not result in any population level effects, death or injury to Pacific white-sided dolphin.

6.11.5.11 Stejneger's Beaked Whale

There is no density information available for Stejneger's beaked whale so the density and results from modeling of Cuvier's beaked whale was used as a surrogate. This analysis, therefore, estimates there would be 2,302 Stejneger's beaked whale MMPA Level B harassments from non-TTS as estimated via the risk function methodology for Cuvier's beaked whales (Table 6-7). This analysis also indicates there would be six MMPA Level B harassments from TTS resulting from exposure to accumulated acoustic energy at or above 195 dB re 1 μPa^2-s. No Stejneger's beaked whales would be exposed to sound levels that could cause MMPA Level A harassment from use of sonar in the TMAA.

Without consideration of clearance procedures, there would be four MMPA Level B harassment from sub-TTS resulting from exposure to accumulated acoustic energy at or above 177 dB re 1 μPa^2-s for MSE. There would be one MMPA Level B harassment from TTS as a result of at-sea explosions with exposures at or above 182 dB re 1 μPa^2-s or at 23 psi. There would be no MMPA Level A harassment and no predicted exposure that would exceed the mortality threshold (Table 6-10).

Given the size (up to 15.5 ft. [4.7 m]) of individual Stejneger's beaked whales, aggregation of 2.3 animals, it is likely that lookouts may detect a group of Stejneger's beaked whales at the surface although beaked whales make prolonged dives that can last up to an hour (Baird et al. 2004). The implementation of mitigation measures to reduce exposure to high levels of sonar sound, and the short duration and intermittent exposure to sonar, reduces the likelihood that exposure to sonar sound would cause a behavioral response that may affect vital functions (reproduction or survival), TTS, or PTS.

Target area clearance procedures, which are part of the Navy's standard mitigation measures, reduce the likelihood that Stejneger's beaked whales will be exposed to at sea explosions associated with Navy training events. The set up procedures and checks required for safety of event participants make it unlikely Stejneger's beaked whales would remain in an area undetected before explosive detonation occurred.

At this time, Navy requests authorization for the annual harassment of 2,313 Stejneger's beaked whales by MMPA Level B harassment (2,308 from sonar and five from at-sea explosions) and no Stejneger's beaked whales by MMPA Level A harassment from potential exposure to sonar or at-sea explosions. Based on the model results, the nature of the Navy's sonar, behavioral patterns, observations made during past training events, and the planned implementation of mitigation (Section 11.1 for sonar and Section 11.2 for at-sea explosions) measures, the Navy finds that the GOA training events would not result in any population level effects, death or injury to Stejneger's beaked whales.

6.11.5.12 Northern Elephant Seal

The risk function and Navy post-modeling analysis estimates there would be 2,064 northern elephant seal MMPA Level B harassments from non-TTS as estimated via the risk function methodology (Table 6-7). Modeling indicates there would be no exposures to accumulated acoustic energy above 204 dB re 1 μPa^2-s, which is the threshold established indicative of onset TTS for northern elephant seals. No northern elephant seals would be exposed to sound levels that could cause MMPA Level A harassment from use of sonar in the TMAA.

Without consideration of clearance procedures, there would be four MMPA Level B harassment from sub-TTS resulting from exposure to accumulated acoustic energy at or above 177 dB re 1 μPa^2-s for MSE. There would be one MMPA Level B harassment from TTS as a result of at-sea explosions with exposures at or above 182 dB re 1 μPa^2-s or at 23 psi. There would be no MMPA Level A harassment and no predicted exposure that would exceed the mortality thresholds (Table 6-10).

Because northern elephant seals tend to dive for long periods, 20-30 minutes, and only spend about 10 percent of the time at the surface making them difficult to detect. The implementation of mitigation measures to reduce exposure to high levels of sonar sound, and the short duration and intermittent exposure to sonar, reduces the likelihood that exposure to sonar sound would cause a behavioral response that may affect vital functions (reproduction or survival), TTS, or PTS.

Target area clearance procedures, which are part of the Navy's standard mitigation measures, reduce the likelihood that northern elephant seals will be exposed to at sea explosions associated with Navy training events. The set up procedures and checks required for safety of event participants make it unlikely northern elephant seals would remain in an area undetected before explosive detonation occurred.

At this time, Navy requests authorization for the annual harassment of 2,069 northern elephant seals by MMPA Level B harassment (2,064 from sonar and five from at-sea explosions) and northern elephant seals by MMPA Level A harassment from potential exposure to sonar or at-sea explosions. Based on the model results, the nature of the Navy's sonar, behavioral patterns, observations made during past training events, and the planned implementation of mitigation (Section 11.1 for sonar and Section 11.2 for at-sea explosions) measures, the Navy finds that the GOA training events would not result in any population level effects, death or injury to northern elephant seals.

6.11.5.13 Northern Fur Seal

The risk function and Navy post-modeling analysis estimates there would be 154,144 northern fur seal MMPA Level B harassments from non-TTS as estimated via the risk function methodology (Table 6-7). Modeling also indicates there would be 16 MMPA Level B harassments from TTS resulting from exposure to accumulated acoustic energy at or above 195 dB re 1 μPa^2-s. No northern fur seals would be exposed to sound levels that could cause MMPA Level A harassment from use of sonar in the TMAA.

Without consideration of clearance procedures, there would be 26 MMPA Level B harassment from sub-TTS resulting from exposure to accumulated acoustic energy at or above 177 dB re 1 μPa^2-s for MSE. There would be 16 MMPA Level B harassments from TTS as a result of at-sea explosions with exposures at 182 dB re 1 μPa2-s or at 23 psi. Modeling estimates there would be one MMPA Level A harassment from the onset of slight injury as a result of exposure at 205 dB re 1 μPa2-s or 13 psi-ms. Modeling estimates there would be no exposure that would exceed the onset of extensive lung injury or mortality thresholds (Table 6-10).

Northern fur seals make short duration dives and often rest at the surface (Antonelis et al. 1990) making them detectable to Navy lookouts. The implementation of mitigation measures to reduce exposure to high levels of sonar sound, and the short duration and intermittent exposure to sonar, reduces the likelihood that exposure to sonar sound would cause a behavioral response that may affect vital functions (reproduction or survival), TTS, or PTS.

Target area clearance procedures, which are part of the Navy's standard mitigation measures, reduce the likelihood that northern fur seals will be exposed to at sea explosions associated with Navy training events. The set up procedures and checks required for safety of event participants make it unlikely northern fur seals would remain in an area undetected before explosive detonation occurred. For these reasons, it is unlikely that any MMPA Level A harassment exposures to northern fur seal would occur as a result of training activities involving at-sea explosions.

At this time, Navy requests authorization for the annual harassment of 154,202 northern fur seals by Level B harassment (154,160 from sonar and 42 from at-sea explosions) and no northern fur seals by Level A harassment from potential exposure to sonar or at-sea explosions. Based on the model results, the nature of the Navy's sonar, behavioral patterns, observations made during past training events, and the planned implementation of mitigation (Section 11.1 for sonar and Section 11.2 for at-sea explosions) measures, the Navy finds that the GOA training events would not result in any population level effects, death or injury to northern fur seals.

6.11.6 Summary of Environmental Consequences

Modeling for active sonar use and accounting for rare species in the TMAA estimates there would be 424,620 annual MMPA Level B harassments from non-TTS under the risk function methodology and 931 annual MMPA Level B harassments from TTS. There would be a total of 425,551 MMPA Level B harassment exposures from annual sonar use in the TMAA. Modeling for sonar indicated one annual MMPA Level A harassment from PTS threshold, but this is very unlikely to occur.

Modeling of predicted exposures to at-sea explosions and accounting for rare animals indicate 170 MMPA Level B harassments from sub-TTS and 70 MMPA Level B harassments from TTS. There is a predicted annual total of 240 MMPA Level B Harassment exposures from sound or pressure from at-sea explosions. Modeling predicted four MMPA Level A harassments from PTS associated activities involving at-sea explosives. In addition, there was one predicted mortality (a Dall's porpoise) resulting from predicted cumulative total fractional exposures to 31 psi-ms across two summer exercise time periods and 336 explosive events. This mortality is very unlikely to occur.

In summary, modeling and accounting for rare animals indicates the potential for a total of 425,791 annual exposures NMFS would consider MMPA Level B harassment for military readiness activities associated with Navy training in the TMAA. The modeling results estimate there would be five exposures resulting in MMPA Level A harassment and one predicted mortality. These MMPA Level A harassment exposures are not likely to occur based on factors described previously in more detail in this Section.

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7 IMPACTS TO MARINE MAMMAL SPECIES OR STOCKS

Overall, the conclusions in this analysis finds that impacts to marine mammal species and stocks would be negligible for the following reasons:

- Although the numbers presented in Tables 6-7 and 6-10 represent the total estimated harassments under the MMPA resulting from acoustic impact modeling and accounting for rare species, they are conservative overestimates of MMPA Level B harassments and MMPA Level A harassments given there has been no attempt to factor in a marine mammal's ability to avoid exposure by moving away from an area of training activity among other factors. In addition, the modeling estimates harassment exposures without taking into consideration standard mitigation measures.
- All of the likely exposures of marine mammals to Navy training activities are MMPA Level B behavioral harassment from non-injurious temporary threshold shifts (TTS), non-TTS behavioral disturbance, or sub-TTS behavioral disturbance. Five exposures to sound levels or pressure that could cause permanent threshold shift (PTS) or direct physiological injury (MMPA Level A harassment) and one exposure to pressure that could result in mortality resulted from the summation of the modeling. However, given the mitigation measures in place, there should be no exposures to sound levels or pressure that would cause a permanent threshold shift (PTS) or direct physiological injury (Marine Mammal Protection Act (MMPA) Level A harassment).
- Additionally, the mitigation measures described in Chapter 11 are designed to reduce sound exposure of marine mammals to levels below those that may cause behavioral disruptions resulting from TTS exposures and to achieve the least practicable adverse effect on marine mammal species or stocks while undertaking Navy training activities.

Consideration of negligible impact is required for National Marine Fisheries Service (NMFS) to authorize incidental take of marine mammals. By definition, an activity has a "negligible impact" on a species or stock when it is determined that the total taking is not likely to reduce annual rates of adult survival or recruitment (i.e., offspring survival, birth rates). Based on each species' life history information, the expected behavioral patterns in the Temporary Maritime Activities Area (TMAA), and an analysis of the behavioral disturbance levels in comparison to the overall population, an analysis of the potential impacts of the Proposed Action on species recruitment or survival is presented in Section 6.5.4 and 6.5.5 for each species. These species-specific analyses support the conclusion that training events proposed for the TMAA would have a negligible impact on marine mammals.

As noted previously, this authorization request assumes that short-term non-injurious sound exposure levels predicted to cause TTS, non-TTS, or sub-TTS behavioral disruptions qualify as MMPA Level B harassment for military readiness activities. As discussed, the acoustic impact modeling and accounting for rare species will overestimate reactions qualifying as harassment under MMPA for military readiness activities because there is no established scientific correlation between sonar exposure and long term abandonment or significant alteration of behavioral patterns in marine mammals. As detailed in Table 6-7 and Table 6-10, the total estimated MMPA Level B harassment exposures are 425,781 (includes sonar and other sound sources non-TTS and TTS and at-sea explosions sub-TTS and TTS). The total MMPA Level A harassment exposures resulting from acoustic impact modeling are four; however, no MMPA Level A harassments are requested by the Navy in this authorization request since they are unlikely to occur.

Neither NMFS nor the Navy anticipates that marine mammal strandings or indirectly caused mortality will result from the use of mid-frequency sonar, other sound sources, or at-sea explosions during Navy exercises within the TMAA. However, to allow for scientific uncertainty, the Navy will request authorization for take, by indirectly caused mortality, of three beaked whales of the Ziphidae family, to include any combination of Baird's beaked whale, Cuvier's beaked whale, Stejneger’s beaked whale, and Mesoplodon sp.

8 ANTICIPATED IMPACTS ON SUBSISTENCE USE

Subsistence use of marine mammals that may occur within the Gulf of Alaska (GOA) Temporary Maritime Activities Area (TMAA) include harbor seals, northern fur seals, Steller sea lions, and gray whales. The TMAA is, however, not an area where hunting or harvesting of these species takes place. Any behavioral effects for animals in the TMAA are likely to be temporary in duration and should not result in the abandonment of locations outside the TMAA where subsistence use takes place. Analysis of the proposed training activities, taking into consideration Navy's standard mitigation measures, indicates it is unlikely that any mortalities to these species as a result of Navy training so there should be no reduction in the numbers of animals present in the GOA. Therefore Navy training activities in the TMAA will not affect the availability of marine mammal species or stock for taking for subsistence use.

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9 IMPACTS TO MARINE MAMMAL HABITAT AND LIKELIHOOD OF RESTORATION

The primary source of potential marine mammal habitat impact is acoustic exposures resulting from anti-submarine warfare (ASW) activities. These acoustic exposures, however, do not constitute a long-term physical alteration of the water column or bottom topography, as the occurrences are of limited duration due to the constant movement of exercise participants. Surface vessels associated with the activities are spread widely and are continuously and relatively rapidly moving through any given area. Activities involving explosive sources, such as bombing exercises (BOMBEX), gunnery exercises (GUNEX), and use of Extended Echo Ranging/Improved Extended Echo Ranging (EER/IEER) sonobuoys do not constitute a long-term physical alteration of the water column or bottom topography, as the occurrences are of very limited duration and are intermittent.

There are no designated critical habitats or known breeding areas, mating grounds or areas of similar significance within the Temporary Maritime Activities Area (TMAA). Most of the area within the TMAA could potentially be utilized for active sonar activities or at-sea explosions. For some of the large mysticetes (i.e., humpback and gray whales), there are known mating and calving grounds are located in southern waters where they overwinter. For odontocetes in the TMAA (such as the abundant Dall's porpoise), much remains unknown regarding mating, but it is presumed that these species mate throughout their habitat and possibly throughout the year. Even less is known about the mating habits of beaked whales. The Navy assumes that active sonar activities could take place within potential mating areas of these toothed whale species within the TMAA, although current state of knowledge is very limited and there may be seasonal components to distribution that could account for breeding activities outside of the TMAA.

There are no activities taking place near pinniped rookeries or haul out locations. The TMAA is adjacent to portions of designated critical habitat for Steller sea lions. This critical habitat incorporates the major extent of the area used for offshore feeding/foraging by Steller sea lions. Given the temporary and isolated nature of potential effects associated with Navy activities, it is unlikely there would be a significant impact (if any) on this habitat.

9.1 WATER QUALITY

Potential impacts on water quality result from expended training materials in the marine environment. Expended materials that contain hazardous constituents may affect water quality because hazardous materials can be released during use (i.e., combustion byproducts), directly deposited into the marine environment (i.e., residual explosive material), or leach from expended materials after deposition. There are several sources of hazardous chemicals from expended training materials such as sonobuoys, targets, (Expendable Mobile ASW Training Target [EMATT]), pyrotechnics or chaff, torpedoes or explosive constituents associated with a Missile Exercise, Gunnery Exercise, Bombing Exercise, and SSQ-110A sonobuoys.

Sonobuoys are designed to be expended upon completion of training exercises. Scuttled sonobuoys sink to the ocean floor, where they are subjected to the corrosion and sedimentation caused by ocean currents. Occasionally, an expended sonobuoy may become flotsam if it fails to be scuttled. Sonobuoys as flotsam move with ocean currents until they either sink or are washed ashore. Scuttled sonobuoys contain a small amount of hazardous materials, but do not pose a threat to public safety, water quality, or biological resources. Hazardous materials leach slowly, and are not expected to substantially affect the environment.

Sonobuoys contain other metal and nonmetal components, such as metal housing (nickel-plated, steel-coated with polyvinyl chloride [PVC] plastics to reduce corrosion), batteries, lead solder, copper wire, and lead ballast that, over time, can release hazardous constituents into the surrounding water. Most of the other sonobuoy components are either coated with plastic to reduce corrosion or are solid metal. The slow rate at which solid metal components corrode in seawater translates into slow release rates into the marine environment. Once the metal surfaces corrode, the rates at which metals are released into the environment decrease. Releases of chemical constituents from metal and nonmetal sonobuoy components are further reduced by encrustation of exposed surfaces by benthic organisms. Therefore, toxic components of the sonobuoy do not substantially degrade marine water quality.

EMATTs use lithium sulfur dioxide batteries. An evaluation of lithium-sulfide dioxide batteries in the marine environment (CFMETR 2005) concluded that: "The standard lithium-sulfur dioxide battery theoretically presents little or no acute or chronic danger to the marine environment. The battery consists of seven material components, and each has been considered in terms of environmental exposure. In each case, it was determined that immersion in seawater would result in the formation of either water-soluble or chemically inert waste products. These will be infinitely dispersible and virtually unsusceptible to significant accumulation." The ocean currents would greatly diffuse concentrations of the chemicals leached by EMATT batteries within a short period. Therefore, lithium batteries would not be expected to substantially affect water quality because of the low amount of reactants remaining after use and the low concentration of leaching materials.

Flares, TALDs, chaff, and MK-58 marine markers will not be recovered. Flares typically contain approximately 0.85 lb of residual pyrotechnic material, which is considered to be hazardous. The marker itself is not designed to be recovered, and will eventually sink to the bottom and become encrusted or incorporated into the sediments. Phosphorus contained in the marker will settle to the ocean floor, where it will react with the water to produce phosphoric acid until all phosphorus is consumed. Combustion of red phosphorus produces phosphorus oxides, which have a low toxicity to aquatic organisms. Red phosphorus released during training is not anticipated to substantially affect the marine environment (DoN 2006). The amount of pyrotechnic material will not affect water or sediment quality because most of the material will be consumed during combustion and the remaining amounts will be dispersed over a large area.

A review of numerous toxicological studies indicated that the principal components of chaff are unlikely to have significant effects on humans and the environment, based on the general toxicity of the components, the dispersion patterns, and the unlikelihood of the components to interact with other substances in nature to produce synergistic toxic effects (USAF 1997). In addition, available evidence suggests that chaff use does not result in significant accumulation of aluminum in sediments after prolonged training. Sediment samples collected from an area of the Chesapeake Bay where chaff had been used for approximately 25 years indicated that aluminum concentrations in sediments were not significantly different than background concentrations (Wilson et al. 2002).

MK-48 Advanced Capability (ADCAP) torpedoes would be used in the TMAA the Proposed Action. Torpedoes typically contain hazardous materials such as propellants, petroleum products and lubricants, components of guidance systems and instrumentation, and explosives in warheads. Most of the explosive is consumed upon detonation of the torpedo. Otto Fuel II is a liquid propellant used in the ADCAP torpedo and may be toxic to marine organisms (DoN 1996b,c). There have been approximately 30,000 exercise test runs of the MK-48 torpedo over the last 25 years (DoN 1996c). Most of these launches have been on Navy test ranges, where there have been no reports of deleterious effects on marine water quality from OTTO Fuel II or its combustion products (DoN 1996b,c). Furthermore, Navy studies conducted at torpedo test ranges that have lower flushing rates than the open ocean did not detect residual OTTO Fuel II in the marine environment (DoN 1996b,c). Thus, no adverse effects are anticipated from use of this fuel.

Exhaust products from the combustion of OTTO Fuel II include NO_x, CO, carbon dioxide (CO_2), hydrogen (H_2), nitrogen (N_2), methane (CH_4), ammonia (NH_3), and hydrogen cyanide (HCN) (DoN

1996b,c). These combustion products are released to the ocean, where they are dissolved, disassociated, or dispersed in the water column. These combustion products are not expected to substantially affect the marine environment. Except for HCN, combustion products are not a concern (DoN 1996b,c). However, because it is very soluble in seawater, HCN will be diluted to less than 1 µg/L at 17.7 ft (5.4 m) from the center of the torpedo's path when first discharged, and thus should pose no substantial threat to water quality.

The explosive components from weapons (associated with MISSLEX, GUNEX, BOMBEX) and SSQ-110A sonobuoys are mostly consumed during operation of the item, leaving only residues. The principal source of potential impacts on water and sediment quality from spent missiles will be unburned solid propellant residue and batteries. Solid propellant fragments will sink to the ocean floor and will undergo changes in the presence of seawater. The propellant concentration will decrease over time as the leaching rate decreases and further dilution occurs. The aluminum will remain in the propellant binder, and eventually will be oxidized by seawater to aluminum oxide. The remaining binder material and aluminum oxide will pose no threat to the marine environment (DoN 1996d).

For the larger at-sea explosions (5-inch, 76mm, and bombs) there is no significant effect to water quality from the remnant explosive residue given its dispersal in atmosphere and the water column or the metal shrapnel. Explosives are generally insoluble in water, and will leach slowly into the marine environment. Explosive material will break down on the ocean floor, and will not accumulate over time. Ocean currents will disperse leaching materials quickly. Bomb casings may contain anti-corrosion coatings and metals, but these substances typically constitute less than one percent of the casing's weight. Bomb casings will degrade slowly, and leaching will be further slowed by encrusting and sedimentation.

Only a very small percentage of the available hydrogen fluoride explosive product in the explosive source sonobuoy (SSQ-110A) is expected to become solubilized prior to reaching the surface and the rapid dilution would occur upon mixing with the ambient water. As such, there would be no significant effect to water quality from the explosive product associated with the explosive source sonobuoy (SSQ-110A).

In summary, there would be no significant effect to water quality from seawater batteries, lithium batteries, and thermal batteries associated with scuttled sonobuoys, EMATT, or resulting from activities involving at-sea explosions.

9.2 SOUND

9.2.1 Sound in the Environment

The potential cumulative impact issue associated with Navy training activities is the addition of underwater sound to oceanic ambient noise levels, which in turn could have potential effects on marine animals. Anthropogenic sources of ambient noise that are most likely to have contributed to increases in ambient noise levels are commercial fishing and shipping vessels, offshore oil and gas exploration and drilling, and use of sonar by the Navy, researchers, and commercial fishermen (Advisory Committee On Acoustic Impacts to Marine Mammals 2006). The potential impact that sonars may have on the overall oceanic ambient noise level are reviewed in the following contexts:

- Recent changes to ambient sound levels in the Pacific Ocean;
- Operational parameters of the sonar operating during TMAA activities, including proposed mitigation;
- The contribution of active sonar activities to oceanic noise levels relative to other human-generated sources of oceanic noise; and

- Cumulative impacts and synergistic effects.

Sources of oceanic ambient noise, include physical, biological, and anthropogenic sounds. Very few studies have been conducted to determine ambient sound levels in the ocean. In a study conducted by Andrew et al. (2002), ocean ambient sound from the 1960s was compared to ocean ambient sound from the 1990s for a receiver off the coast of California (DoN 2007c). The data showed an increase in ambient noise of approximately 10 decibels (dB) in the frequency range of 20 to 80 hertz (Hz), and 200 to 300 Hz, and about 3 dB at 100 Hz over a 33-year period (DoN 2007c). Ambient sound levels for the Eglin Gulf Test and Training Range, located in the Gulf of Mexico, generally range from approximately 40 dB to about 110 dB (Department of the Air Force, 2002). Au et al. (2000b) determined that the most dominant underwater sounds in the Hawaiian Islands during the 6-month November to April period are the vocalizations of the humpback whales. The ambient sound pressure level (SPL) of 120 dB occurs during this period as a result of thousands of whale “songs” having source levels as high as 174 dB SPL and other whale vocalizations and noises (e.g., flipper slaps) having source levels as high as 192 dB SPL (Richardson et al., 1995; Au et al., 2000b)

Anthropogenic sound can be introduced into the ocean by a number of sources, including vessel traffic, industrial operations onshore, seismic profiling for oil exploration, oil drilling, and sonar use by shipping vessels, commercial fishermen, researchers (fisheries and geophysical), and by the military. In open oceans, the primary persistent anthropogenic sound source tends to be commercial shipping, since over 90 percent of global trade depends on transport across the seas (Scowcroft et al., 2006). Moreover, there are approximately 20,000 large commercial vessels at sea worldwide at any given time. The large commercial vessels produce relatively loud and predominately low-frequency sounds. Most of these sounds are produced as a result of propeller cavitation (when air spaces created by the motion of propellers collapse) (Southall 2005). In 2004, the National Oceanic and Atmospheric Administration (NOAA) hosted a symposium entitled, “Shipping Noise and Marine Mammals.” During Session I, Trends in the Shipping Industry and Shipping Noise, statistics were presented that indicate foreign waterborne trade into the United States has increased 2.45 percent each year over a 20-year period (1981 to 2001) (Southall 2005). International shipping volumes and densities are expected to continually increase in the foreseeable future (Southall 2005). The increase in shipping volumes and densities will most likely increase overall ambient sound levels in the ocean. However, it is not known whether these increases would have an effect on marine mammals (Southall 2005).

According to the National Research Council (2003), the oil and gas industry has five categories of activities which create sound: seismic surveys, drilling, offshore structure emplacement, offshore structure removal, and production and related activities. Seismic surveys are conducted using air guns, sparker sources, sleeve guns, innovative new impulsive sources and sometimes explosives, and are routinely conducted in offshore exploration and production operations in order to define subsurface geological structure. The resultant seismic data are necessary for determining drilling location and currently seismic surveys are the only method to accurately find hydrocarbon reserves. Since the reserves are deep in the earth, the low-frequency band (5 to 20 Hz) is of greatest value for seismic surveys, because lower frequency signals are able to travel farther into the seafloor with less attenuation (DoN 2007a).

The air gun firing rate is dependent on the distance from the array to the substrate. The typical intershot time is 9 to 14 seconds, but for very deep water surveys, inter-shot times are as high as 42 seconds. Air gun acoustic signals are broadband and typically measured in peak-to-peak pressures. Peak levels from the air guns are generally higher than continuous sound levels from any other ship or industrial noise. Broadband SLs of 248 to 255 dB from zero-to-peak are typical for a full-scale array. The most powerful arrays have source levels as high as 260 dB, zero to-peak with air gun volumes of 130 L (7,900 in^3). Smaller arrays have SLs of 235 to 246 dB, zero-to peak.

For deeper-water surveys, most emitted energy is around 10 to 120 Hz. However, some pulses contain energy up to 1,000 Hz (Richardson et al. 1995), and higher. Drill ship activities are one of the noisiest at-sea activities because the hull of the ship is a good transmitter of all the ship's internal noises. In addition, the ships use thrusters to stay in the same location rather than anchoring. Auxiliary noise is produced during drilling activities, such as helicopter and supply boat noises. Offshore drilling structure emplacement creates some localized noise for brief periods of time, and emplacement activities can last for a few weeks and occur worldwide. Additional noise is created during other oil production activities, such as borehole logging, cementing, pumping, and pile driving. Although sound pressure levels for some of these activities have not yet been calculated, others have (e.g., pile-driving). These oil and gas industry activities occur year-round (not individual surveys, but collectively) and are usually operational 24 hours per day and 7 days per week.

There are both military and commercial sonars: military sonars are used for target detection, localization, and classification; commercial sonars are typically higher in frequency and lower in power and are used for depth sounding, bottom profiling, fish finding, and detecting obstacles in the water. Commercial sonar use is expected to continue to increase, although it is not believed that the acoustic characteristics will change. Even though an animal's exposure to active sonar may be more than one time, the intermittent nature of the sonar signal, its low duty cycle, and the fact that both the vessel and animal are moving provide a very small chance that exposure to active sonar for individual animals and stocks would be repeated over extended periods of time, such as those caused by shipping noise.

In Alaska waters, Alaska Fisheries Science Center (AFSC) conducts annual echo integration-trawl (EIT) surveys with a Simrad ER60 scientific echo sounding system transmitting sonar at 18, 38, 120, and 200 kilohertz (kHz) with split beam transducers (Honkalehto et al. 2008). The reported source level for this system is approximately 224 to 240 dB referenced to 1 micropascal at 1 meter (re µPa @ 1 m) as required by the depth being surveyed (Mitson 1995, Gardner and Mayer 1998). As an example of area covered, a NOAA EIT survey for walleye pollock in the Bearing Sea covered 1,870 square nautical miles (nm^2; 6,414 square kilometer [km^2]) over an 11-day period in March 2007 (Honkalehto et al. 2008). This duration of sonar use is similar to that which would be likely during the proposed Navy exercise involving Anti-Submarine Warfare (ASW) training.

In the summer of 2003, EIT fishery research in the Shelikof Strait (north of Kodiak), Cook Inlet, Prince William Sound and on the shelf between Kodiak and Montague Island was combined with a cetacean survey during which there were 392 sightings of 1,254 cetaceans including beaked whales and Endangered Species Act (ESA) listed species (Waite 2003). The behavioral and physiological effects on marine mammals from exposure to fisheries sonar are unknown.

9.2.2 Navy Training Effects on Marine Mammal Prey

9.2.2.1 Fish Resources

The data obtained to date on effects of sound on fish are very limited both in terms of number of well controlled studies and in number of species tested. Moreover, there are significant limits in the range of data available for any particular type of sound source. Finally, most of the data currently available has little to do with actual behavior of fish in response to sound in their normal environment. As discussed, the extent of data, and particularly scientifically peer-reviewed data, on the effects of high intensity sounds on fish is exceedingly limited (Popper et al. 2007, Popper 2008). Some of these limitations include:

Types of sources tested; Effects of individual sources as they vary by such things as intensity, repetition rate, spectrum, distance to the animal, etc.; Number of species tested with any particular source; The ability to extrapolate between species that are anatomically, physiologically, and/or taxonomically, different; Potential differences, even within a species as related to fish size (and mass) and/or developmental history; Differences in the sound field at the fish, even when studies have used the same type of sound source (e.g., seismic airgun); Poor quality experimental design and controls in many of the studies to date; Lack of behavioral studies that examine the effects on, and responses of, fish in their natural habitat to high intensity signals; Lack of studies on how sound may impact stress, and the short- and long-term effects of acoustic stress on fish; and Lack of studies on eggs and larvae that specifically use sounds of interest to the Navy.

At the same time, in considering potential sources that are in the mid- and high-frequency range, a number of potential effects are clearly eliminated. Most significantly, the vast majority of fish species studied to date are hearing generalists and cannot hear sounds above 500 to 1,500 Hz (0.5 to 1.5 kHz) (depending upon the species). For this reason, the vast majority of fish (including salmon and other important commercial fish and their prey) are not likely to experience behavioral effects as a result of exposure to sonar, given they cannot hear in that frequency range.

Moreover, even those marine species that may hear above 1.5 kHz, such as a few sciaenids and the clupeids (and relatives), have relatively poor hearing above 1.5 kHz as compared to their hearing sensitivity at lower frequencies. Thus, it is reasonable to suggest that even among the species that have hearing ranges that overlap with some mid- and high-frequency sounds, it is likely that the fish will only actually hear the sounds if the fish and source are very close to one another. And, finally, since the vast majority of sounds that are of biological relevance to fish are below 1 kHz (e.g., Zelick et al. 1999, Ladich and Popper 2004), even if a fish detects a mid- or high-frequency sound, these sounds will not mask detection of lower frequency biologically relevant sounds. Thus, a reasonable conclusion, even without more data, is that there will be few, and more likely no, impacts on the behavior of fish from sonar. Any hypothetical impacts to fish should also be placed in context with the known impact resulting from the annual landing from commercial fisheries averaging 600-700 thousand tons in the Gulf of Alaska (GOA; Aquaron and Adams 2008).

9.2.2.2 Invertebrates Food Resources

Very little is known about sound detection and use of sound by invertebrates (see Popper et al. 2001 for review). The limited data shows that some crabs are able to detect sound, and there has been the suggestion that some other groups of invertebrates are also able to detect sounds. In addition, cephalopods (octopus and squid) and decapods (lobster, shrimp, and crab) are thought to sense low-frequency sound (Budelmann 1992b). Packard et al. (1990) reported sensitivity to sound vibrations between 1-100 Hz for three species of cephalopods. McCauley et al. (2000) found evidence that squid exposed to seismic airguns show a behavioral response including inking. However, these were caged animals, and it is not clear how unconfined animals may have responded to the same signal and at the same distances used. In another study, Wilson et al. (2007) played back echolocation clicks of killer whales to two groups of squid (*Loligo pealeii*) in a tank. The investigators observed no apparent behavioral effects or any acoustic debilitation from playback of signals up to 199 to 226 dB re 1 μPa. It should be noted, however, that the lack of behavioral response by the squid may have been because the animals were in a tank rather than being in the wild. In another report on squid, Guerra et al. (2004) claimed that dead giant squid turned up around the time of seismic airgun operations off of Spain. The authors suggested, based on analysis of carcasses, that the damage to the squid was unusual when compared to other dead squid found at other times. However, the report presents conclusions based on a correlation to the time of finding of the carcasses and seismic testing, but the evidence in support of an effect of airgun activity was totally circumstantial. Moreover, the data presented showing damage to tissue is highly questionable since there was no way to differentiate between damage due to some external cause (e.g., the seismic airgun) and normal tissue degradation that takes place after death, or due to poor fixation and preparation of tissue. To date, this work has not been published in peer reviewed literature, and detailed images of the reportedly damaged tissue are also not available.

At the same time, it is possible that very intense mid- and high-frequency signals, and particularly explosives, could have a physical impact on fish, resulting in damage to the swim bladder and other organ systems. However, even these kinds of effects have only been shown in a few cases in response to explosives, and only when the fish has been very close to the source. Such effects have never been shown to result from any Navy sonar. Moreover, at greater distances (the distance clearly would depend on the intensity of the signal from the source) there appears to be little or no impact on fish, and particularly no impact on fish that do not have a swim bladder or other air bubble that would be affected by rapid pressure changes.

Any potential for effects to fish in the TMAA as a result of Navy training activities should be viewed in context of the actual impacts from commercial fisheries in the GOA. Aquarone and Adams (2008) report the total landings from the various fisheries in GOA is on the order of 600 to 700 thousand tons annually.

In summary, baleen whales feed on the aggregations of krill and small schooling fish, while toothed whales feed on epipelagic, mesopelagic, and bathypelagic fish and squid. As presented above in more detail, potential impacts to marine mammal food resources within the GOA is negligible given both lack of hearing sensitivity to mid-frequency sonar by fish, the very geographic and spatially limited scope of most Navy at sea activities including at-sea explosions, and the high biological productivity of these resources. No short or long term effects to marine mammal food resources from Navy activities associated with the use of sonar or resulting in at-sea explosions are anticipated.

9.3 VESSEL MOVEMENT

Collisions with ships can cause major wounds and may occasionally cause fatalities to cetaceans. The most vulnerable marine mammals are those that spend extended periods of time at the surface in order to restore oxygen levels within their tissues after deep dives (e.g., sperm whale). In addition, some baleen whales, such as the northern right whale and fin whale swim slowly and seem generally unresponsive to ship sound, making them more susceptible to ship strikes (Nowacek et al. 2004). Smaller marine mammals, for example, the delphinids move quickly throughout the water column and are often seen riding the bow wave of large ships. Marine mammal responses to vessels may include avoidance and changes in dive pattern (National Research Council 2003).

Unlike many commercial and recreational ships and boats, Navy ships usually maintain as low a speed as practical in terms of the tactical and transit considerations for a particular event in order to economize on fuel and associated fuel costs. In addition, each Navy vessel has at least three personnel maintaining a visual search of the surrounding water during non-ASW events, and five personnel during ASW-events. Not included in this count are additional observers involved with safe navigation (Officer of the Deck, Conning Officer, and other personnel on the bridge watch).

The Navy has adopted mitigation measures that reduce the potential for collisions with surfaced marine mammals (See Section 11). These standard operating procedures include: (1) use of lookouts trained to detect all objects on the surface of the water, including marine mammals; (2) reasonable and prudent actions to avoid the close interaction of Navy vessels and marine mammals; and (3) maneuvering to keep away from any observed marine mammal. Based on these standard operating procedures, collisions with marine mammals are not expected.

Expendable Devices

Marine mammals are subject to entanglement by anything incorporating loops or rings, hooks and lines, or sharp objects. Most documented cases of entanglements occur when whales encounter the vertical lines of fixed fishing gear. This section summarizes the potential effects of materials from expendable devices on marine mammals. Expendable devices associated with Navy training include sonobuoys, flares, markers, parachutes, and some targets.

Some materials associated with expendable devices may be encountered by marine mammals in the waters of the TMAA. This material is not recovered and generally sinks within a short period of time; the amount that might remain on or near the sea surface is low, and the density of such material in the TMAA would be very low.

Entanglement in material associated with expendable devices was not cited as a source of injury or mortality for any marine mammals recorded in a large marine mammal and sea turtle stranding database for California waters, an area with much higher density of marine mammals and level of training activities that proposed for GOA. Therefore as discussed in this Letter of Authorization (LOA) request, expendable material is highly unlikely to directly affect marine mammal habitat within the TMAA.

9.4 LIKELIHOOD OF HABITAT RESTORATION

Effects to marine mammal habitat from Navy training activities will be short in duration and/or limited in area. Previous main impacts to marine mammal habitat in the GOA include urban pollution, fisheries removal of prey and bottom trawling practice, and oil spills. Navy training activities will neither contribute to nor hinder the likelihood of habitat restoration in the GOA or TMAA.

9.5 SUMMARY

Based on the discussion in this section, there will be no effects to marine mammals resulting from loss or modification of marine mammal habitat including changes to water quality, food resources, or as a result of vessel movement, or use of expendable material and ordnance. Marine mammal habitat would not be affected by Navy training activities to any degree that would have consequences for marine mammal populations inhabiting the TMAA. Navy training activities will neither contribute to nor hinder the likelihood of habitat restoration.

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10 IMPACTS TO MARINE MAMMALS FROM LOSS OR MODIFICATION OF HABITAT

Based on the discussions in Chapter 9, there will be no impacts to marine mammals resulting from loss or modification of marine mammal habitat. There is no designated critical habitat within the Temporary Maritime Activities Area (TMAA).

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11 MEANS OF EFFECTING THE LEAST PRACTICABLE ADVERSE IMPACTS – MITIGATION MEASURES

Effective training in the Gulf of Alaska (GOA) Temporary Maritime Activities Area (TMAA) dictates that ship, submarine, and aircraft participants utilize their sensors and exercise weapons to their optimum capabilities as required by the training mission. The Navy recognizes that such use has the potential to cause behavioral disturbance to some marine mammal species in the vicinity of training (as outlined in Chapter 6). This Section presents the Navy's mitigation measures, outlining steps that would be implemented to protect marine mammals and Federally-Endangered Species Act (ESA) listed species during training activities. It should be noted that many of these mitigation measures have been standard operating procedures for unit level Anti-Submarine Warfare (ASW) training since 2004. In addition, the Navy coordinated with the National Marine Fisheries Service (NMFS) to further develop measures for protection of marine mammals during the period of the National Defense Exemption, and those mitigations for mid-frequency active (MFA) sonar are detailed subsequently in this Section. This Section also presents a discussion of other measures that have been considered but not adopted because they were determined either (1) not feasible, (2) to present a safety risk, (3) to provide no known or ambiguous protective benefit, or (4) to have an unacceptable impact on training fidelity.

A Letter of Instruction, Mitigation Measures Message, or Environmental Annex to the Operational Order will be issued prior to each exercise to further disseminate the personnel training requirement and general marine mammal mitigation measures including monitoring and reporting.

This section includes 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 generally to all Navy training at sea. The Navy will continue to fund marine mammal research as outlined in Chapter 14.

11.1 GENERAL MARITIME MEASURES

11.1.1 Personnel Training – Watchstanders and Lookouts

The use of shipboard lookouts is a critical component of all Navy mitigation 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. MSAT training must be reviewed at least annually and again prior to the first use of mid-frequency active (MFA) sonar and/or IEER during major ASW exercises (e.g., Composite Training Unit Exercise [COMPTUEX] and Rim of the Pacific Exercise [RIMPAC]). This training must be recorded in the individual's training record.
- Navy lookouts will undertake extensive training 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 watchstander. 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). Personnel being trained as lookouts can be counted among required lookouts as 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 to facilitate implementation of mitigation measures if marine species are spotted.
- Lookouts' ability to detect objects in the water, including marine mammals and sea turtles, is critical to Navy environmental compliance and will be evaluated by Navy and contracted biologists.

11.1.2 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 to further disseminate the personnel training requirement and general marine species mitigation measures.
- COs 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 MFA sonar, pedestal mounted "Big Eye" (20x110) binoculars will be properly installed and in good working order to assist in the detection of marine mammals 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.
- After sunset and prior to sunrise, lookouts will employ Night Lookout Techniques in accordance with the Lookout Training Handbook.
- 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 OOD, 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. Navy environmental compliance relies heavily on the abilities of lookouts to detect and avoid protected species. Therefore, it is critical that lookouts be vigilant in their reporting.
- 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 sea turtles or 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 at least 1,500 ft (500 yds) away from any observed whale in the vessel's path and avoid approaching whales head-on. These requirements do 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 activities, launching and recovering aircraft or landing craft, minesweeping activities, replenishment while underway and towing activities that severely restrict a vessel's ability to deviate course. Vessels will take reasonable steps to alert other vessels in the vicinity of the whale. Given rapid swimming speeds and maneuverability of many dolphin species, naval vessels would maintain normal course and speed on sighting dolphins unless some condition indicated a need for the vessel to maneuver.
- Floating weeds and kelp, algal mats, clusters of seabirds, and jellyfish are good indicators of marine mammals. Therefore, where these circumstances are present, the Navy will exercise increased vigilance in watching for marine mammals.
- Navy aircraft participating in exercises at sea will conduct and maintain, when operationally feasible and safe, surveillance for marine mammals 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 when 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.
- All vessels will maintain logs and records documenting training operations 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.

11.2 MEASURES FOR SPECIFIC TRAINING EVENTS

Mid-Frequency Active Sonar Activities

General Maritime Mitigation Measures: Personnel Training

- All lookouts onboard platforms involved in ASW training events will review the NMFS-approved MSAT material prior to use of MFA sonar.
- All COs, XOs, 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 lookouts will undertake extensive training in order to qualify as a watchstander in accordance with the Lookout Training Handbook.
- Lookout training will include on-the-job instruction under the supervision of a qualified, experienced watchstander. 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 forbid 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 mitigation measures if marine species are spotted.

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.
- Personnel on lookout will employ visual search procedures employing a scanning methodology in accordance with the Lookout Training Handbook.
- After sunset and prior to sunrise, lookouts will employ Night Lookout Techniques in accordance with the Lookout Training Handbook.
- 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 OOD, 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.

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 mitigation measures.
- COs and OICs 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. Only the sonobuoys that are impacted by the mammal presence within 200 yd (183 m) need to be used in passive mode.
- 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 or closing to inside 1,000 yd (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.
    - Ships and submarines will continue to limit maximum transmission levels by this 6-dB factor until the animal has been seen to leave the 1,000-yd safety zone, has not been detected for 30 minutes, or the vessel has transited more than 2,000 yd (1,829 m) beyond the location of the last detection.
    - Should a marine mammal be detected within or closing to inside 500 yd (457 m) of the sonar dome, active sonar 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 animal has been seen to leave the 500-yd safety zone, has not been detected for 30 minutes, or the vessel has transited more than 2,000 yd (1,829 m) beyond the location of the last detection.
    - Should the marine mammal be detected within or closing to inside 200 yd (183 m) of the sonar dome, active sonar transmissions will cease. Sonar will not resume until the animal has been seen to leave the 200-yd safety zone, has not been detected for 30 minutes, or the vessel has transited more than 2,000 yd (1,829 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 OOD 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 will 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 active sonar was being operated).
- Prior to start up or restart of active sonar, operators will check that the Safety Zone radius around the sound source is clear of marine mammals.
- Active sonar levels (generally)—Navy will operate active sonar at the lowest practicable level, not to exceed 235 dB, except as required to meet tactical training objectives.
- Helicopters will observe/survey the vicinity of an ASW training event for 10 minutes before the first deployment of active (dipping) sonar in the water.
- Helicopters will not dip their active sonar within 200 yd (183 m) of a marine mammal and will cease pinging if a marine mammal closes within 200 yd (183 m) after pinging has begun.
- Submarine sonar operators will review detection indicators of close-aboard marine mammals prior to the commencement of ASW training events involving MFA sonar.
- Night vision goggles will be available to all ships and air crews, for use as appropriate.
- Increased vigilance during major ASW training exercise with tactical active sonar when critical conditions are present.

    The Navy should avoid planning major ASW training exercises with MFA sonar in areas where they will encounter conditions which, in their aggregate, may contribute to a marine mammal stranding event. Of particular concern are beaked whales, for which strandings have been associated with MFA sonar operations.

The conditions to be considered during exercise planning include:

- Areas of at least 1,000 m (3,280 ft) depth near a shoreline where there is a rapid change in bathymetry on the order of 1,000-6,000 m (3,280-19,685 ft) occurring across a relatively short horizontal distance (e.g., 5 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 operations involving multiple ships/submarines (≥ 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 significant surface duct (i.e., a mixed layer of constant water temperature extending from the sea surface to 100 ft [30 m] or more).

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. Requests to conduct an exercise that meet these conditions must be sent to the applicable U.S. Navy Component Commander no later than 90 days prior to the scheduled exercise. At a minimum, the request must contain dates of the exercise, location, participating units, and anticipated total time of MFA sonar use. The Navy will increase vigilance under these circumstances by undertaking the following additional mitigation measures:

- A dedicated aircraft (Navy or contracted) will conduct 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, the advance survey should occur within 2 hours prior to MFA sonar use, and periodic surveillance should continue for the duration of the exercise. Any sightings of sensitive species, groups of species milling out of habitat, and any stranded animals, shall be reported to the Office in Tactical Command, who should give consideration to delaying, suspending, or altering the exercise.
- All safety zone power-down requirements described above apply.
- The post exercise report must include specific reference to any event conducted in areas where the above conditions exist, with exact location, time, and duration of the event, and noting results of surveys conducted.

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

- Lookouts will visually survey for floating weeds and kelp. Intended impact (i.e., where the Navy is aiming) will not be within 600 yd (549 m) of known or observed floating weeds and kelp, and algal mats.
- A 600 yd (549 m) radius buffer zone will be established around the intended target.
- From the intended firing position, lookouts will survey the buffer zone for marine mammals prior to commencement and during the exercise as long as practicable.
- For exercises using targets towed by a vessel or aircraft, target-towing vessels/aircraft will maintain a trained lookout for marine mammals, if applicable. If a marine mammal is sighted in the vicinity, the tow aircraft/vessel will immediately notify the firing vessel, which will suspend the exercise until the area is clear.

- The exercise will be conducted only when the buffer zone is visible and marine mammals are not detected within it.

Surface-to-Surface Gunnery (nonexplosive rounds)

- Lookouts will visually survey for floating weeds and kelp, and algal mats. Intended impact will not be within 200 yd (183 m) of known or observed floating weeds and kelp, and algal mats.
- A 200 yd (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 prior to commencement and during the exercise as long as practicable.
- If applicable, target towing vessels will maintain a lookout. If a marine mammal 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 are not detected within the target area and the buffer zone.

Surface-to-Air Gunnery (explosive and nonexplosive 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.
- Target towing aircraft will maintain a lookout, if applicable. If a marine mammal is sighted in the vicinity of the exercise, the tow aircraft will immediately notify the firing vessel in order to secure gunnery firing until the area is clear.

Air-to-Surface Gunnery (explosive and nonexplosive rounds)

- If surface vessels are involved, lookouts will visually survey for floating kelp in the target area. Impact will not occur within 200 yd (183 m) of known or observed floating weeds and kelp or algal mats.
- A 200 yd (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 prior to and during the exercise.
- Aerial surveillance of the buffer zone for marine mammals will be conducted prior to commencement of the exercise. 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 are not visible within the buffer zone.

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

- If surface vessels are involved, trained lookouts will survey for floating kelp and marine mammals. Ordnance will not be targeted to impact within 1,000 yd (914 m) of known or observed floating kelp 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 prior to and during the exercise. The survey of the impact area will be made by flying at 1,500 ft (457 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 exercises will be conducted only if marine mammals are not visible within the buffer zone.

Air-to-Surface Missile Exercises (explosive and nonexplosive)

- Ordnance will not be targeted to impact within 1,800 yd (1,646 m) of known or observed floating kelp.
- Aircraft will visually survey the target area for marine mammals. Visual inspection of the target area will be made by flying at 1,500 ft (457 m) or lower, if safe to do so, and at slowest safe speed. Firing or range clearance aircraft must be able to actually see ordnance impact areas. Explosive ordnance will not be targeted to impact within 1,800 yd (1646 m) of sighted marine mammals.

Sinking Exercise (SINKEX)

The selection of sites suitable for SINKEX involves a balance of operational suitability and requirements established under the Marine Protection, Research and Sanctuaries Act (MPRSA) permit granted to the Navy (40 Code of Federal Regulations § 229.2). To meet operational suitability criteria, locations must be within a reasonable distance of the target vessels' originating locations. 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 1,000 fathoms (6,000 ft [2,000 yds/1,829 m]) deep and at least 50 nm (92.6 km) from land.

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

SINKEX Mitigation Plan

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

- All weapons firing will be conducted during the period one 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 1.5 nm will be established around each target. This 1.5 nm zone includes a buffer of 0.5 nm to account for errors, target drift, and animal movement. In addition to the 1.5 nm exclusion zone, a further safety zone, which extends from the exclusion zone at 1.5 nm out an additional 0.5 nm, will be surveyed. Together, the zones (exclusion and safety) extend out 2 nm from the target.
- A series of surveillance over-flights will be conducted within the exclusion and the safety zones, prior to and during the exercise, when feasible. Survey protocol will be as follows:
    - Overflights within the exclusion zone will 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 will be conducted by Navy personnel trained in visual surveillance. At least one member of the mitigation team will have completed the Navy's marine mammal training program for lookouts.
  - In addition to the overflights, the exclusion zone will 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 any vocalizing marine mammals (particularly sperm whales) in the vicinity of the exercise. The sonobuoys will 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 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 will commence two hours prior to the first firing.
  - The results of all visual, aerial, and acoustic searches will be reported immediately to the OCE. No weapons launches or firing may commence until the OCE declares the safety and exclusion zones free of marine mammals.
  - If a protected species observed within the exclusion zone is diving, firing will 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.
  - During breaks in the exercise of 30 minutes or more, the exclusion zone will again be surveyed for any protected species. If marine mammals 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 will be monitored for two hours, or until sunset, to verify that no marine mammals were harmed.

- Aerial surveillance will 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.
- Where practicable, the Navy will conduct the exercise in sea states that are ideal for marine mammal sighting, i.e., Beaufort Sea State Level 3 or less. In the event of a Level 4 or above, survey efforts will be increased within the exercise area. This will be accomplished through the use of an additional aircraft, if available, and conducting tight search patterns.
- The exercise will not be conducted unless the exclusion zone can be adequately monitored visually.

- In the event that any marine mammals are observed to be harmed in the area, a detailed description of the animal will be taken, the location noted, and if possible, photos taken. This information will be provided to NMFS via the Navy chain of command for purposes of identification (see the Stranding Plan for detail).
- An after action report detailing the exercise 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 will be submitted to NMFS.

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

AN/SSQ-110A Pattern Deployment

- Crews will conduct visual reconnaissance of the drop area prior to laying their intended sonobuoy pattern. This search will be conducted below 1,500 ft (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 will conduct a minimum of 30 minutes of visual and aural monitoring of the search area prior to commanding the first post (source/receiver sonobuoy pair) 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 yd (914 m) of observed marine mammal activity, the Navy will deploy the receiver ONLY and monitor while conducting a visual search. When marine mammals are no longer detected within 1,000 yd (914 m) of the intended post position, the Navy will co-locate the explosive source sonobuoys (AN/SSQ-110A) (source) with the receiver.
- When able, Navy crews will conduct continuous visual and aural monitoring of marine mammal activity. This is to include monitoring of aircraft sensors from first sensor placement to checking off-station and out of Radio Frequency (RF) range of these sensors.

AN/SSQ-110A Pattern Employment

- Aural Detection:
    - If the presence of marine mammals is detected aurally, then that will cue the Navy aircrew to increase the diligence of their visual surveillance.
    - Subsequently, if 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 yd (914 m) of the explosive source sonobuoys (AN/SSQ-110A) intended for use, then that payload will not be detonated. Aircrews may utilize this post once the marine mammals have not been re-sighted for 30 minutes, or are observed to have moved outside the 1,000 yd (914 m) safety buffer. Aircrews may shift their multi-static active search to another post where marine mammals are outside the 1,000 yd (914 m) safety buffer.

AN/SSQ-110A Scuttling Sonobuoys

- Aircrews will 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 will refrain from using the “Scuttle” command when two payloads remain at a given post. Aircrews will ensure a 1,000 yd (914 m) safety buffer, visually clear of marine mammals, is maintained around each post as is done during active search operations.

- Aircrews will 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.
- The Navy will ensure all payloads are accounted for. Explosive source sonobuoys (AN/SSQ-110A) that cannot be scuttled will be reported as unexploded ordnance via voice communications while airborne, then upon landing via naval message.
- Mammal monitoring will continue until out of own-aircraft sensor range.

11.3 CONSERVATION MEASURES

Monitoring: Integrated Comprehensive Monitoring Program

The U.S. Navy is committed to demonstrating environmental stewardship while executing its National Defense mission and is responsible for compliance with a suite of federal environmental and natural resources laws and regulations that apply to the marine environment. As part of those responsibilities, an assessment of the long-term and/or population-level effects of Navy training activities as well as the efficacy of mitigation measures is necessary. The Navy is developing an Integrated Comprehensive Monitoring Program (ICMP) for marine species in order to assess the effects of training activities on marine species and investigate population trends in marine species distribution and abundance in various range complexes and geographic locations where Navy training occurs. This program will emphasize active sonar training.

The primary goals of the ICMP are to:

- Monitor Navy training events, particularly those involving MFA sonar and at sea explosions, for compliance with the terms and conditions of Endangered Species Act (ESA) Section 7 consultations or Marine Mammal Protection Act (MMPA) authorizations;
- Collect data to support estimating the number of individuals exposed to sound levels above current regulatory thresholds;
- Assess the efficacy of the Navy's current marine species mitigation;
- Add to the knowledge base on potential behavioral and physiological effects to marine species from mid-frequency active sonar and underwater detonations; and,
- Assess the practicality and effectiveness of a number of mitigation tools and techniques (some not yet in use).

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) exposed 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 important 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/High-Frequency Active (HFA) sonar (or explosives or other stimuli) that we associate with specific adverse effects, such as behavioral harassment, Temporary Threshold Shift (TTS), or Permanent Threshold Shift (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.

Research

The Navy provides a significant amount of funding and support to marine research. In the past 5 years the agency funded over $100 million ($26 million in Fiscal Year [FY] 08 alone) to universities, research institutions, federal laboratories, private companies, and independent researchers around the world to study marine mammals. The U.S. 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 and during training,
- Understanding the effects of sound on marine mammals, sea turtles, fish, and birds, and
- Developing tools to model and estimate potential effects of sound.

This research is directly applicable to Fleet 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 active 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:

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

The Navy has also developed the technical reports referenced within this document, including the Marine Resource Assessment. Furthermore, research cruises by the National Marine Fisheries Service (NMFS) and by academic institutions have received funding from the U.S. Navy. For example, in April 2009, the Navy funded a vessel-based line-transect survey in the GOA on board the NOAA ship *Oscar Dyson* to determine marine mammal species distribution and abundance. The survey cruise employed multiple observation techniques, including visual and passive acoustic observations, as well as photographic identifications (Rone et al. 2009).

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 literature for research and development efforts; and future research as described previously.

11.4 COORDINATION AND REPORTING

The Navy will coordinate with the local NMFS Stranding Coordinator for any unusual marine mammal behavior and any stranding, beached live/dead or floating marine mammals that may occur coincident with Navy training activities.

11.5 ALTERNATIVE MITIGATION MEASURES CONSIDERED BUT ELIMINATED

As described in Chapter 3, Section 3.9 and Appendix B, the vast majority of estimated sound exposures of marine mammals in the GOA during proposed active sonar activities would not cause injury. Potential acoustic effects on marine mammals would be reduced by the mitigation measures described previously. Therefore, the Navy concludes the Proposed Action and mitigation measures would achieve the least practical adverse impact on species or stocks of marine mammals.

A determination of "least practicable adverse impacts" includes the following factors relative to one another: (1) the manner in which, and the degree to which, the successful implementation of the measure is expected to minimize adverse impacts to marine mammals; (2) the proven or likely efficacy of the specific measure to minimize adverse impacts as planned; and (3) the practicability of the measure for Navy implementation, which includes consideration of personnel safety, practicality of implementation, and the impact on the effectiveness of the military readiness activity. Accordingly, the following additional mitigation measures were analyzed and eliminated from further consideration:

Seasonal and/or Geographic Limitations:

Benefit to Marine Mammals/Effectiveness of Measure

In previous documents NMFS has indicated that seasonal or geographic limitations are a direct and effective means of reducing adverse impacts to marine mammals. By reducing the overlap in time and space of the known concentrations of marine mammals and the acoustic footprint associated with the thresholds for the different types of take (either at all times and places where animals are concentrated, or times and places where they are concentrated for specifically important behaviors [such as reproduction or feeding]), the amount of take can be reduced.

However, the concept of geographical and seasonal (or temporal) limitations is inconsistent with the Title 10 responsibilities of Department of Defense to assure a fully trained and ready military force in regards to training activities in the GOA. Such restrictions would not be appropriate in the GOA. The training area locations utilized in the GOA were very carefully chosen by planners based on training requirements and the ability of ships, aircraft, and submarines to operate safely. Moving the training activities to alternative locations would impact the effectiveness of the training and has no known benefit.

It is important that any measures are used carefully at times and places where their effects are relatively well known. For example, if there is credible evidence that concentrations of marine mammals are known to be high at a specific place or during a specific time of the year, or that certain areas are selectively used for important life functions like breeding or feeding (such as the high densities of humpback whales in the main Hawaiian Islands, or North Atlantic right whale critical habitat on the east coast), then these types of seasonal or geographic exclusions or limitations can be effective. However, if marine mammals are only known to prefer certain types of areas (as opposed to specific areas) for certain functions (such as beaked whales use of seamounts or marine mammal use of productive areas like fronts), which means that they may or may not be present at any specific time, it may be less effective to require avoidance or limited use of that type of area all of the time.

In the GOA, for the purposes of this EIS/OEIS, the Navy has no plans to conduct sonar training, and only very minimal underwater explosive training, in the Inshore Area where the Southern Resident killer whale critical habitat is located. The Navy will abide by the standard 3,000-ft aquatic and aerial restrictions designated for Stellar Sea Lion critical habitat on the coast.

Practicability of the Measure

Generally speaking, and specifically discussed in Chapter 2 of the EIS/OEIS, the Navy needs to have the flexibility to operate at any time or place to meet their training needs pursuant to Title 10. The Navy needs to be able to train in the largest variety of physical (bathymetry, etc.), environmental, and operational (within vicinity of different assets, such as airfields, instrumented ranges, homeports, etc.) parameters in order to be properly prepared. Additionally, Navy training, planning and implementation needs to be adaptable in order to accommodate the need of the Navy to respond to world events and the ever-changing strategic focus of the U.S. The Navy has always expressed a need to maintain the flexibility to train in an area if necessary for national security, and any measures imposed by NMFS need to account for this reality.

Aside from the general reasons of impracticability cited above, below are some of the specific reasons that certain specific types of seasonal and geographic restrictions or limitations are impracticable for the Navy.

Coastal restrictions (such as 25 nm from 200-m isobath) - Littoral waterspace is where potential enemies will operate. The littoral waterspace is also the most challenging area to operate due to a diverse acoustic environment. In real world situations, it is highly likely the Navy would be working in these types of areas. It is not realistic to refrain from training in the areas that are the most challenging and operationally important. Areas where ASW events are scheduled to occur are carefully chosen to provide for the safety of events and to allow for the realistic development of the training scenario including the ability of the exercise participants to develop, maintain, and demonstrate proficiency in all areas of warfare simultaneously. Limiting the training event to a few areas would have an adverse impact on the effectiveness of the training by limiting the ability to conduct other critical warfare areas including, but not limited to, the ability of the Strike Group to defend itself from threats on the surface and in the air while carrying out air strikes and/or amphibious assaults. In those locations where amphibious landing events occur, coastal restrictions would decouple ASW training and Amphibious training, which are critically important to be conducted together due to the high risk to forces during actual Amphibious operations. Furthermore, training activities using integrated warfare components require large areas of the littorals and open ocean for realistic and safe training.

Sea Mounts and Canyons- Submarine tracking is a long and complicated tactical procedure. Seamounts are often used by submarines to hide or mask their presence, requiring the need to train in this complex ocean environment. This is precisely the type of area needed by the Navy to train. Sea mounts and canyons impact the way sound travels in water as well as the Navy's ability to search and track submarines. If the Navy does not train near sea mounts and canyons and understand how these features affect their ability to search and track a submarine, they will be unable to do so when faced with an actual threat. Exercise locations are carefully chosen based on training requirements and the ability of ships, aircraft, and submarines to operate safely. Given the strategic training needs, restricting active sonar operation around seamounts and canyons in the TMAA is not practicable. This discussion considers the impracticability of avoiding all seamounts and canyons. While it may be somewhat less impracticable to avoid a subset of specific seamounts or canyons, marine mammal use of these areas is ephemeral and varies based on many changing factors, which would make it difficult to justify requiring the avoidance of any particular features since doing so may or may not benefit marine mammals at any particular time.

Fronts and other Major Oceanographic Features – NMFS has determined that the impracticability to the Navy of avoiding these features outweighs the potential conservation gain. Though many species may congregate near fronts and other major oceanographic features, these areas may be both large and transitory, so restricting access to these features to avoid animals that may congregate in a small subset of the total areas is not practicable. Additionally, limiting sonar use in the vicinity of these types of features would disrupt training for the reasons described above for sea mounts and canyons.

Use of Dedicated or Independent Marine Mammal Observers (MMOs) to Implement Mitigation:

Benefit to Marine Mammals/Effectiveness of Measure

Navy lookouts are specifically trained to detect anything (living or inanimate) that is in the vicinity of, visible from, or approaching the vessel. The safety of the personnel on board and of the vessel depends on their performance. While they receive training that is intended to expose them to the different species of marine mammals they might see and the behaviors they might potentially observe, they would certainly not be expected to differentiate between species or identify the significance of a behavior as effectively as an independent MMO. However, identification to species and understanding of marine mammal behavior is not necessary for mitigation implementation – for that, a lookout must simply detect a marine mammal and estimate its distance (e.g., within 1000 yds, 500 yds, or 200 yds) to the vessel. Though dedicated and independent MMOs are critical to implement a Monitoring Plan, Navy lookouts performing their normal duties are expected to be effective at detecting marine mammals for mitigation implementation.

Practicability of the Measure

Following are several reasons for why using third-party observers from air or surface platforms, in addition to or instead of the existing Navy-trained lookouts is not practicable.

- The use of third-party observers could compromise security due to the requirement to provide advance notification of specific times/locations of Navy platforms.
- Reliance on the availability of third-party personnel would also impact training flexibility, thus adversely affecting training effectiveness. The presence of other aircraft in the vicinity of naval exercises would raise safety concerns for both the commercial observers and naval aircraft.
- Use of Navy observers is the most effective means to ensure quick and effective implementation of mitigation measures if marine species are spotted. A critical skill set of effective Navy training is communication. Navy lookouts are trained to act swiftly and decisively to ensure that appropriate actions are taken.
- Security clearance issues would have to be overcome to allow non-Navy observers onboard exercise platforms.
- Some training events will span one or more 24-hour period(s), with operations underway continuously in that timeframe. It is not feasible to maintain non-Navy surveillance of these operations, given the number of non-Navy observers that would be required onboard.
- Surface ships with active mid-frequency sonar have limited berthing capacity. Exercise planning includes careful consideration of this limited capacity in the placement of exercise controllers, data collection personnel, and Afloat Training Group personnel on ships involved in the exercise. 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 exercise objectives.
- Aerial surveying during an event raises safety issues with multiple, slow civilian aircraft operating in the same airspace as military aircraft engaged in combat training activities. In addition, most of the training events take place far from land, limiting both the time available for civilian aircraft to be in the exercise area and presenting a concern should aircraft mechanical problems arise.
- Scheduling civilian vessels or aircraft to coincide with training events would impact training effectiveness, since exercise event timetables cannot be precisely fixed and are instead based on the free-flow development of tactical situations. Waiting for civilian aircraft or vessels to

complete surveys, refuel, or be on station would slow the progress of the exercise and impact the effectiveness of the military readiness activity.

- Multiple events may occur simultaneously in areas at opposite ends of the TMAA and continue for multiple days at a time. There are not enough qualified third-party personnel to accomplish the monitoring task.

Use of Additional Detection Methods to Implement Mitigation (Shutdown Zones):

Benefit to Marine Mammals/Effectiveness of Measure

Lookouts stationed on surface vessels are currently the primary component of the Navy's marine mammal detection capabilities, with some opportunistic assistance from aerial or passive acoustic platforms when such assets are participating in a given exercise. The use of additional detection methods, such as those listed in Section 5.2.1.2, for the implementation of mitigation might further minimize the Level A and Level B take of marine mammals. Specifically, passive and active acoustic methods may detect animals that were below the surface (for passive acoustic detection, the animals would have to be vocalizing to be detected, but for active acoustic detection they would not – the HFM3 system utilized by LFA sonar vessels effectively detects marine mammals to within 1 km of the sonar source).

In order for additional marine mammal detection methods to assist in the implementation of mitigation (shutdown and powerdown), they must be able to localize, or identify where the marine mammal is in relation to the sound source of concern (since shutdown and powerdown mitigation is triggered by the distance from the sound source), and transmit the applicable data to the commanding officer in real time (i.e., quickly so that the sonar source can be turned down or shut off right away or the explosive detonation can be delayed). A limited number of techniques based on the real-time participation of additional observers (such as additional aerial platforms) can achieve this, while many passive acoustic methods cannot. The section below contains information that speaks both to the practicality of implementation of some methods as well as the effectiveness.

Practicability of the Measure

Radars - While Navy radars are used to detect objects at or near the water surface, radars are not specifically designed to search for and identify marine mammals. For example, when an object is detected by radar, the operators cannot definitively discern that it is a whale. During a demonstration project at Pacific Missile Range Facility (PMRF) in Hawaii, radar systems were only capable of detecting whales under very controlled circumstances and when these whales were already visually spotted by lookouts/watchstanders. Enhancing radar systems to detect marine mammals requires additional resources to schedule, plan and execute Navy limited objective experiments (LOEs) and RDT&E events. The Navy is currently reviewing opportunities to pursue enhancing radar systems and other developmental methods such as laser detection and ranging technology as potential mitigation for detecting marine mammals. Until funding resources and the data are available to develop enhanced systems, it is not known whether it will be technically feasible in the future to implement radar as an additional detection method.

Additional Platforms (aerial, UAV, Gliders, and Other**)** - The number of aerial and unmanned aerial vehicle (UAV) systems currently integrated into fleet training is extremely low and their availability for use in most training events is rare; therefore, shifting their use and focus from hunting submarines to locating marine mammals would be costly and negatively impact the training objectives related to these systems. If additional platforms are civilian, scheduling civilian vessels or aircraft to coincide with training events would affect training effectiveness since exercise events or timetables are not fixed and are based on a free flow development of tactical situations. Waiting for civilian aircraft or vessels to complete surveys, refuel, or be on station would slow the required progress of the training exercise. In addition, the precise location data and exercise plans provided to non-Navy assets poses logistical challenges and classification or security issues. While the Navy is currently reviewing options for additional detection methods, these additional platforms proved to be impracticable for the following reasons:

- Additional Aerial Survey Detection: Airborne assets when available already monitor for the presence of marine mammals with no reported incidents where marine mammals were overlooked during an exercise or where aerial assets were unable to perform their duties while watching for marine mammals; therefore, the allocation of additional airborne assets is not well justified. In addition, the presence of additional aircraft (not involved in the exercise) near naval exercises would present safety concerns for both commercial and naval observers because ASW training exercises are dynamic, can last several hours or days, and cover large areas of ocean several miles from land.
- UAV Detection: Currently and in the foreseeable five-year period of the requested authorization, these assets are extremely limited and are rarely if ever available and, therefore, impractical and expensive.
- Gliders Detection: Gliders are not currently capable of providing real time data and, therefore, are not an effective detection method for use in mitigation implementation.

Active Sonar - As previously noted, the Navy is actively engaged in acoustic monitoring research involving a variety of methodologies; however, none of the methodologies have been developed to the point where they could be used as a mitigation tool for MFAS or HFAS. At this time, the active sonar and adjunct systems listed below proved to be impracticable for the following reasons:

- Use of multiple systems (meaning the MFAS used for the exercise plus any additional active system used for marine mammal detection) operating simultaneously increases the likelihood that a submarine may be detected under conditions where it is attempting to mask its presence before activating sonar, resulting in an impact to the effectiveness of the military readiness activity. Additionally, interference may occur when certain active sonar systems (such as HFM3) are activated concurrently with MFAS.
- HFM3 is an adjunct system used by LFA because the hulls of those platforms can be modified and travel can occur at slow speeds. MFAS combatants are not equipped with HFM3 systems and it is impractical to install such a system on MFAS combatants.

The Navy will continue to coordinate acoustic monitoring and detection research specific to the proposed use of active sonar. As technology and methodologies become available, their applicability and viability will be evaluated for potential future incorporation.

Additional Passive Acoustic Monitoring - To provide a specialized localization capability (distance, direction, etc.), most of the systems (Sonobuoys, SQQ89, Bottom-Mounted Sensors) would require significant modifications. The Navy is working to develop or enhance systems with distance measuring capabilities. Until these capabilities are available, exercise participants can use these systems to aid in marine mammal detection, but not solely to implement mitigation measures. Although passive contact on marine mammals only indicates the presence, not the range (distance and direction), the information on any passive acoustic detections is disseminated real time to allow lookouts to focus their visual search for marine mammals.

The Navy is improving the capabilities to use range instrumentation to aid in the passive acoustic detection of marine mammals. At the Southern California Offshore ASW Range (SOAR) in the SOCAL Range Complex, development of effective passive acoustic detection as part of the instrumented range is progressing fairly rapidly. Passive acoustic monitoring has the potential to significantly improve the ability to detect marine mammal presence within SOAR. The Navy sponsored Marine Mammal Monitoring on Navy Ranges (M3R) program has developed hardware and software that leverages the SOAR sensors to detect and localize marine mammal vocalizations. Localization is possible when the same signal is detected, precisely time-tagged, and associated on at least three sensors. Prototype M3R systems have been installed on both the AUTEC (Bahamas) and SOAR ranges.

The M3R system is capable of monitoring all the range hydrophones in real-time. The Navy is refining the M3R system by developing tools to display detected transient signals including marine mammal vocalizations and localizations. The tools operate in real-time and are being used in a series of tests to document marine mammal species, their vocalizations, and their distribution on the SOAR range. In addition, they are being used to collect and analyze opportunistic data at AUTEC, and as part of the on-going Behavioral Response Study (BRS) there.

Reliable automated methods are needed for detection and classification of marine mammal calls to allow range hydrophones to be used for routine marine mammal monitoring in SOAR. The performance of these hydrophones must be quantified. The calls of many baleen whale species are stereotyped and well known. Identification of stereotyped mysticete calls within SOAR has been accomplished using automatic detectors. However, the full range of mysticete call types that are expected within SOAR is not known (e.g., sei whales). Odontocete call identification is more difficult owing to their call complexity. Calls of some odontocetes, such as sperm whales, killer whales, and porpoises, are easily distinguishable. For most species, however, the variation in and among call types is a topic of current research. Likewise, pinniped call types are complex and more data are needed to develop automatic detectors and classifiers to allow automated identification for pinniped species within SOAR. The Navy continues to develop this technology.

At SOAR the large number of species and high animal density combined with imprecise acoustic localization makes the efficacy of such monitoring for use for mitigation implementation during real-time operations questionable.

Prior to implementation of real-time passive acoustic monitoring for use in mitigation, the species present and their distribution should be established. A system must be implemented on range and Detection, Classification, and Localization (DCL) algorithms specific to these species must be developed and tests with visual observers must be conducted to verify their performance. The Navy continues to work on this, and such systems are not yet available for consideration as required mitigation.

Infrared technology – As a complement to existing methods, use of the Infrared (IR) band for marine mammal detection and location has some obvious benefits if proved viable, including the ability to operate infrared at night, as well as the ability to establish automated detections procedures which might well reduce the factor of human fatigue that affects observer-based methods. The Navy has committed to a program of research, development, and testing of IR-based technologies for detection of marine mammals in the wild.

The Navy program will have two main thrusts. NAVAIR will continue to pursue operational tests of their airborne monitoring and mitigation program for marine species using net-centric Intelligence, Surveillance, and Reconnaissance (ISR) systems. The proposed system uses a radar detect and track cueing sensor for a turreted airborne Electro-Optic/Infrared/Multi-spectral imaging sensor. If fully funded for prototyping and demonstration, this program would evaluate the efficacy for marine mammal detection of a large, high-powered system designed, tested, and deployed for other purposes, and operates beyond the domain of research Science and Technology.

At the same time, the Office of Naval Research (ONR) will take the lead in pursuing a longer-range, research S&T program to evaluate new concepts for IR detection that may ultimately lead to an operationally viable technique(s). The focus of the ONR effort will be on comparatively small, low-power systems that might be deployable on small, robot aircraft known as Unmanned Aerial Vehicles (UAVs) as well as operating in a ship-based mode. Either option might allow the inclusion of standard video for confirmation of mammal detections during the day. The UAV option might allow for multiple passages of an area of interest at low altitude to confirm mammal detections and identification.

ONR will continue to support this effort for at least several years, with the potential for sustained support, though the future breadth of this program will depend on the outcome of early efforts. The system is not considered practicable to require for implementation at this time.

Avoidance of Federal and State Marine Protected Areas:

Benefit to Marine Mammals/Effectiveness of Measure

Pursuant to the MMPA, NMFS makes decisions regarding required mitigation based on biological information pertaining to the potential impacts of an activity on marine mammals and their habitat (and the practicability of the measure), not management designations intended for the broad protection of various other marine resources.

As mentioned previously, no known areas of specific importance to marine mammals (that would benefit from a training restriction, i.e., not counting pinniped haulouts where the animals are not in the water the majority of the time) are present within these designated areas. Therefore, limiting activity in these areas would be of questionable value to marine mammals.

Practicability of the Measure

As discussed above, these measures would not offer any additional benefit to marine mammals. Additionally, the impracticability of seasonal and geographic restrictions and limitations, which applies to this measure, is discussed above.

Suspension of MFAS Training at Night, or During Low Visibility or Surface Duct:

Benefit to Marine Mammals/Effectiveness of Measure

The Navy is capable of ***effectively monitoring*** a 1000-yd safety zone using night vision goggles and passive acoustic monitoring (infrared cameras are sometimes used as an extra tool for detection, when available, but have not been shown to show a significant enhancement of current capabilities). Night vision goggles are always available to all vessel and aircrews as needed and passive acoustic monitoring is always in use. As mentioned previously, the estimated zone in which TTS may be incurred is within about 140 m of the sound source (830 m for harbor seals), and the estimated zone for injury is within 10 m of the sonar dome. The powerdown and shutdown zones are at 1000, 500, and 200 yds. The Navy is expected to be able to effectively implement the necessary mitigation measures during nighttime and times of lower visibility.

Because of the limited visibility beyond 1000 yards, Navy personnel could potentially detect fewer animals early (outside of the 1000 yds), as they are approaching to within 1000 yd, which could result in a slightly delayed powerdown or shutdown as compared to when operations are conducted in full daylight. However, any such potential delays would be at the outer edge of the safety zone and would not result in an animal being exposed to received sound levels associated with TTS or injury. So, suspension of MFAS during times of lower visibility may slightly reduce the exposures of marine mammals to levels associated with behavioral harassment, but would not reduce the number of marine mammals exposed to sound levels associated with TTS or injury.

Regarding surface ducts, their presence is based on water conditions in the exercise areas, is not uniform, and can change over a period of a few hours as the effects of environmental conditions such as wind, sunlight, cloud cover, and tide changes alter surface duct conditions. Across a typical exercise area, the determination of “significant surface ducting” is continually changing, and this mitigation measures cannot be accurately implemented. Furthermore, surface ducting alone does not necessarily increase the risk of MFA sonar impacts to marine mammals. While 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 rms at approximately 1,100 yards (assuming the nominal source of 235 dB rms), even in significant surface ducting conditions.

Practicability of the Measure

ASW training using MFAS is required year round in all environments, to include nighttime and low visibility conditions or conditions that realistically portray bathymetric features where adversary submarine threats (i.e., extremely quite diesel electric or nuclear powered) can hide and present significant detection challenges. Unlike an aerial dogfight, which is over in minutes or even seconds, ASW is a cat and mouse game that requires large teams of personnel working in shifts around the clock (24-hours) typically over multiple days to complete an ASW scenario. ASW can take a significant amount of time to develop the tactical picture (i.e., understanding of the battle space such as area searched or unsearched, identifying false contacts, and water conditions). Reducing or securing power at night or in low visibility conditions would affect a Commander's ability to develop the tactical picture as well as not provide the needed training realism. If there is an artificial break in the exercise by reducing power or suspending MFAS use, the flow of the exercise is lost and several hours of training will have been wasted. Both lost time and training differently than what would be needed in combat diminish training effectiveness.

MFAS training at night is vital because differences between daytime and nighttime affect the detection capabilities of MFAS systems. Ambient noise levels are higher at night because many species use the nighttime period for foraging and movement. Temperature layers, which affect sound propagation, move up and down in the water column from day to night. Consequently, personnel must train during all hours of the day to ensure they identify and respond to changing environmental conditions. An ASW team trained solely during the day cannot be sent on deployment and be expected to fight at night because they would not identify and respond to the changing conditions.

Finally, as a matter of safety and international law, Navy vessels are required to use all means available in restricted visibility, including MFAS and positioning of additional lookouts, to provide heightened vigilance to avoid collision. The *International Navigation Rules of the Road* considers periods of fog, mist, falling snow, heavy rainstorm, sandstorms, or any similar events as "restricted visibility." In restricted visibility, all mariners, including Navy vessel crews, are required to maintain proper lookout by sight and hearing as well as "by all available means appropriate in the prevailing circumstances and conditions so as to make a full appraisal of the situation and of the risk of collision." Prohibiting or limiting vessels from using sensors like MFAS during periods of restricted visibility violates international navigational rules, increases navigational risk, and jeopardizes the safety of the vessel and crew.

Surface ducting occurs when water conditions (e.g., temperature layers, lack of wave action) result in sound energy emitted at or near the surface to be refracted back up to the surface, then reflected from the surface only to be refracted back up to the surface so that relatively little sound energy penetrates to the depths that otherwise would be expected. This increases active detection ranges in a narrow layer near the surface, but decreases active sonar detection below the thermocline, a phenomenon that submarines have long exploited. Significant surface ducts are conditions under which ASW training must occur to ensure Sailors learn to identify these conditions, how they alter the abilities of MFA sonar systems, and how to deal with the resulting effects on MFA sonar capabilities. To be effective, the complexity of ASW requires the most realistic training possible. Reducing power in significant surface ducting conditions undermines training realism, and is, therefore, impracticable.

Delayed Restart of MFAS after Shutdown or Powerdown:

Benefit to Marine Mammals/Effectiveness of Measure

NMFS' assessment indicates that expanding the delay (until sonar can be restarted after a shutdown due to a marine mammal sighting) for deep-diving species adds minimal protective value for the following reasons:

- The ability of an animal to dive longer than the required shutdown time does not mean that it will always do so. Therefore, the additional delay would only potentially add value in instances when animals had remained under water for longer than the shutdown time required.
- Navy vessels typically move at 10-12 knots (5-6 m/sec) when operating active sonar and potentially much faster when not. Fish et al. (2006) measured speeds of 7 species of odontocetes and found that they ranged from 1.4–7.30 m/sec. Even if a vessel was moving at the slower typical speed associated with active sonar use, an animal would need to be swimming near sustained maximum speed for an hour in the direction of the vessel's course to stay within the safety zone of the vessel (i.e., to be in danger of being exposed to levels of sonar associated with injury or TTS).
- Additionally, the times when marine mammals are deep-diving (i.e., the times when they are under the water for longer periods of time) are the same times that a large portion of their motion is in the vertical direction, which means that they are far less likely to keep pace with a horizontally moving vessel.
- Given that, the animal would need to have stayed in the immediate vicinity of the sound source for an hour and considering the maximum area that both the vessel and the animal could cover in an hour, it is improbable that this would randomly occur. Moreover, considering that many animals have been shown to avoid both acoustic sources and ships without acoustic sources, it is improbable that a deep-diving cetacean (as opposed to a dolphin that might bow ride) would choose to remain in the immediate vicinity of the source. It is unlikely that a single cetacean would remain in the safety zone of a Navy sound source for more than 30 minutes.
- Last, in many cases, the lookouts are not able to differentiate species to the degree that would be necessary to implement this measure. Plus, Navy operators have indicated that increasing the number of mitigation decisions that need to be made based on biological information is more difficult for the lookouts (because it is not their area of expertise).

Practicability of the Measure

When there is an artificial break in the exercise (such as a shutdown) the flow of the exercise is lost and several hours of training may be wasted, depending on where the Navy was in the exercise. An increase in the delay of MFAS use that occurs during an exercise will likely further negatively affect the effectiveness of the military readiness training because it will be harder to regain the flow of the exercise the longer the equipment and personnel are on hold. Moreover, lengthening a delay in training necessitates a continuation of the expenditure of resources (operation of all of the equipment and personnel), while not making progress towards the accomplishment of the mission (training completion).

Halting of MFAS Use in the Event of a Marine Mammal Injury or Death (and Stranding) until Cause is Determined:

Benefit to Marine Mammals/Effectiveness of Measure

Only in a very small portion of incidents (such as when a ship strikes a whale and personnel realize it immediately) is the cause of marine mammal injury or death immediately known. Halting MFAS use in the event of a marine mammal stranding may have only a very limited immediate benefit to marine mammals if animals have stranded and are still in the water and are within a certain distance of a Navy sound source(s) (not to imply that the Navy source would be assumed to have caused the event), i.e., it is physically possible for them to be exposed to received levels of sound that could potentially result in an additional adverse effects. In this case, cessation of sonar may alleviate additional stress to an animal that is already in a compromised physical state. However, if stranded animals are dead or on the beach, the benefit of a cessation of sonar does not exist as neither dead nor beached animals can benefit from it. The Navy only plans to conduct approximately 678 hours of hull-mounted MFAS activity annually in the TMAA. The Navy will be required (by the MMPA authorization) to notify NMFS immediately if an injured, stranded, or dead marine mammal is found during or shortly after, and in the vicinity of, any Navy training exercise utilizing MFAS, HFAS, or underwater explosive detonations taking place within the TMAA.

Practicability of the Measure

Investigations into the causes of stranding events often take months or years and the most probable outcome is that a definitive determination of cause is not made. Despite the fact that the Navy has been conducting thousands of hours of sonar, each, in southern California, the Pacific Northwest, around Hawaii, and off the east coast of the U.S. for multiple years, NMFS and the Navy have concluded that only 5 strandings worldwide (and not in the areas mentioned) can be associated with MFAS use. It is impracticable to halt the use of MFAS while the cause of a stranding is determined.

Ramp Up of Sonar Source Prior to Full Power Operation:

Benefit to Marine Mammals/Effectiveness of Measure

Based on the evidence that some marine mammals avoid sound sources, such as vessels, seismic sources, or MFAS (Richardson et al. 1995, Southall et al. 2007), the theory behind the ramp-up is that animals would move away from a sound source that was ramped up starting at low energy, which would result in the animals not being suddenly exposed to a more alarming, or potentially injurious sound. This response has not been empirically demonstrated and the effectiveness of the measure would likely vary between species and circumstances. The effectiveness of the measure should be the focus of further research (i.e., controlled exposure experiments). 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. With seismic surveys, which have relatively large safety zones compared to MFAS (and for which NMFS estimates that injury can occur at greater distances from the source than MFAS), NMFS utilizes ramp-up as a cautious mitigation measure to reduce Level B harassment and help ensure that Level A harassment does not occur.

Practicability of the Measure

Ramp-up procedures are not a viable alternative for MFA sonar training events as the ramp-up would alert opponents to the participants’ presence, thus undermining training realism and effectiveness of the military readiness activity. When a MFA sonar ship turns its sonar on, area submarines are alerted to its presence. A submarine can hear an active sonar transmission farther away than the surface ship can hear the echo of its sonar off the submarine. Ideally, the surface ship will detect the submarine in time to attack the submarine before the submarine can attack one of the ships of the Strike Group (noting, of course, that attacks during training events are not actual attacks). If the MFA sonar ship starts out at a low power and gradually ramps up, it will give time for the submarine to take evasive action, hide, or close in for an attack before the MFA sonar is at a high enough power level to detect the submarine. Additionally, using these procedures would not allow the Navy to conduct realistic training, or “train as they fight,” thus adversely impacting the effectiveness of the military readiness activity. Ramp up would constitute additional unnecessary sound introduced into the marine environment, in and of itself constituting harassment and this measure does not account for the movement of the ASW participants over the period of time when ramp up would be implemented.

Enlargement or Modification of Powerdown/Shutdown Zones of Hull-mounted Sonar:

Benefit to Marine Mammals/Effectiveness of Measure

The current power down and shut down zones are based on scientific investigations specific to MFA sonar for a representative group of marine mammals. They are 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 MFA sonar. Specifically, the current power-downs at 500 yards and 1,000 yards, as well as the 200 yard shut-down, were developed to minimize exposing marine mammals to sound levels that could cause TTS and PTS. The underlying received levels of sound that were used to determine the appropriate safety zone distances are based on: for TTS - empirical information gathered on the levels at which the onset of noise-induced loss in the hearing sensitivity of captive cetaceans occurs, and, for PTS – extrapolations from the cetacean TTS data that incorporate TTS growth data from terrestrial animals. NMFS has determined that these measures effectively accomplish this.

Enlargement of the powerdown or shutdown zones would primarily result in the further reduction of the maximum received level that the detected animal might be exposed to, which could potentially mean that an animal expected to respond in a manner NMFS would classify as level B harassment could potentially either respond in a less severe manner or maybe not respond at all. This could be more important at an important time or place or in the presence of species or age-classes of concern (such as beaked whales). NMFS has received varying recommendations regarding the potential size of an expanded powerdown or shutdown zone, including 2 km, 4 km, or the 154 dB isopleth. As noted below, the ability of the lookouts to effectively monitor the safety zone decreases as the distance to the edge of the zone increases and the area that it is necessary to monitor increases by a factor of 4 as the distance to the edge doubles.

A review of the Navy's post-exercise reports shows lookouts have not reported any observed response of marine mammals at any distance.

Practicability of the Measure

The outer safety zone the Navy has developed (1000 yd) is also based on a lookout's ability to realistically maintain situational awareness over a large area of the ocean, including the ability to detect marine mammals at that distance during most conditions at sea. Requirements to implement procedures when marine mammals are present well beyond 1,000 yards dictate that lookouts sight marine mammals at distances that, in reality, are not always possible. These increased distances also significantly expand 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. Increases in safety zones are not based in science, provide limited benefit to marine mammals and severely impact realistic ASW training by increasing the number of times that a ship would have to shut down active sonar, impacting realistic training, and depriving ships of valuable submarine contact time. Commanders participating in training designed for locating, tracking, and attacking a hostile submarine could lose awareness of the tactical situation through increased stopping and starting of MFA sonar leading to significant exercise event disruption. Increased shutdowns could allow a submarine to take advantage of the lapses of active sonar, and position itself for a simulated attack, artificially changing the reality of the training activity. Given the operational training needs, increasing the size of the safety range is generally impracticable.

Expansion of Exclusion Area Delineated for Use with Explosive Detonations:

Benefit to Marine Mammals/Effectiveness of Measure

As described previously, the current designated exclusion zones for three exercise types (SINKEX, BOMBEX, and MISSILEX) are not large enough to prevent TTS should one of the largest explosives (MK-82 or Harpoon) detonate while the animal is at some distance outside of the exclusion zone. If the exclusion zone were enlarged, the Navy could theoretically reduce the number of TTS takes that might occur – however, anticipated takes by TTS are already very low, and the exclusion zones are more than large enough to avoid injury from all charges.

Practicability of the Measure

As mentioned above, SINKEXs have associated range clearance procedures that cover a circle with a radius of either 2 nm (though the exclusion zone is only 1 nm), 1,645 m, or 914 m. Enlarging these circles to encompass the TTS isopleths for these exercise means doubling the radius of the exclusion zones (or more), which would mean that an area 4 times the size would need to be monitored. Generally speaking, the Navy could do this in one of two ways: they could either use the same amount of resources to monitor the area that is 4 times larger, which could potentially result in less focus on the center area that is more critical (because more severe effects are expected closer to the source where the received level would be louder), or they could maintain the same level of coverage by increasing the resources used for monitoring by four times (or more), which is not practicable considering the limited anticipated protective value of the measure.

Monitoring of Explosive Exclusion Area During Exercises:

Benefit to Marine Mammals/Effectiveness of Measure

The Navy's SINKEX and BOMBEX measures currently require that the Navy survey a safety zone prior to an exercise, and then during the exercise when feasible. Additionally, passive acoustic means are used to detect marine mammals during the exercise. Continuous monitoring during an explosive exercise could potentially decrease the number of animals exposed to energy or pressure levels associated with take. However, one could assume that animals would continue to avoid the area to some degree if continuous explosions were occurring in the areas.

Of note, aside from SINKEXs, training events involving explosives are generally completed in a short amount of time. For smaller detonations such as those involving underwater demolitions training, the area is observed to ensure all the charges detonated and that they did so in the manner intended; however, it is not possible to have visual contact 100 percent of the time for all explosive in-water events. The Navy must clear all people from the explosive zone of influence prior to an in-water explosive event for the safety of personnel and assets. If there is an extended break between clearance procedures and the timing of the explosive event, clearance procedures are repeated.

Practicability of the Measure

There are potentially serious safety concerns associated with monitoring an area where explosions will occur and the Navy must take those into consideration when determining when monitoring during an exercise is feasible. While the Navy's measures allow for some monitoring during explosive exercises, it is not practicable to do all of the time.

Using MFA and HFA Sonar with Output Levels as Low as Possible Consistent with Mission Requirements or Using Active Sonar Only When Necessary:

Operators of sonar equipment are trained to be aware 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. The Navy remains committed to using passive sonar and all other available sensors in concert with active sonar to the maximum extent practicable consistent with mission requirements.

Scaling Down Training to Meet Core Aims:

As with each Navy range complex, the primary mission of the ATA is to provide a realistic training environment for naval forces to ensure that they have the capabilities and high state of readiness required to accomplish assigned missions. Modern war and security operations are complex. Modern weaponry has brought both unprecedented opportunity and innumerable challenges to the Navy. Smart weapons, used properly, are very accurate and actually allow the military Services to accomplish their missions with greater precision and far less destruction than in past conflicts. But these modern smart weapons are very complex to use. U.S. military personnel must train regularly with them to understand their capabilities, limitations, and operation. Modern military actions require teamwork between hundreds or thousands of people, and their various equipment, vehicles, ships, and aircraft, all working individually and as a coordinated unit to achieve success. These teams must be prepared to conduct activities in multiple warfare areas simultaneously in an integrated and effective manner. Navy training addresses all aspects of the team, from the individual to joint and coalition teamwork. Training events are identified and planned because they are necessary to develop and maintain critical skills and proficiency in many warfare areas. Exercise planners and Commanding Officers are obligated to ensure they maximize the use of time, personnel and equipment during training. The level of training expressed in the Proposed Action and alternatives is essential to achieving the primary mission of the ATA.

Limiting the Active Sonar Event Locations:

Areas where events are scheduled to occur are carefully chosen to provide for the safety of events and to allow for the realistic development of the training scenario including the ability of the exercise participants to develop, maintain, and demonstrate proficiency in all areas of warfare simultaneously. Limiting the training event to a few areas would have an adverse impact to the effectiveness of the training by limiting the ability to conduct other critical warfare areas including, but not limited to, the ability of Navy ships to defend themselves from threats on the surface and in the air while carrying out other activities. Limiting the exercise areas would concentrate all active sonar use, resulting in unnecessarily prolonged and intensive sound levels rather than the more transient exposures predicted by the current planning that makes use of multiple exercise areas. Furthermore, exercises using integrated warfare components require large areas of the littorals and open ocean for realistic and safe training.

Implementing 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 that which would be needed in an actual combat scenario would decrease training effectiveness and reduce the crew's abilities.

The majority of the ships participating in training activities in the TMAA have a number of advantages for avoiding ship strikes as compared to most commercial merchant vessels. These include the following: (1) Navy ships have their bridges positioned forward, offering good visibility ahead of the bow; (2) Crew size is much larger than that of merchant ships, allowing for more potential observers on the bridge; (3) Dedicated lookouts are posted during a training activity scanning the ocean for anything detectable in the water; anything detected is reported to the Officer of the Deck; (4) 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 (5) Navy ships are generally much more maneuverable than commercial merchant ships.

Restricting the Use of MFA Sonar During ASW Training Events While Conducting Transits Between Islands (i.e., Choke-points):

This restriction is not applicable to training in the TMAA. A chokepoint is a strategic strait or canal. Although there are over 200 major straits around the world, only a handful are considered to be strategic "chokepoints," such as the Strait of Gibraltar, Panama Canal, Strait of Magellan, Strait of Malacca, Bosporus and Dardanelles, Strait of Hormuz, Suez Canal, and Bab el Mandeb. While chokepoints are relatively few in number, significant quantities of international commerce and naval shipping move through these chokepoints, making them strategically important to the United States because a single quiet diesel submarine can position itself in the chokepoint and effectively block access beyond that point. The primary similarity of these chokepoints is lengthy shorelines that restrict maneuverability. The longer and more narrow the passage, the more likely the chokepoint creates an area of restricted egress for marine mammals. However these features are not present in the areas of the TMAA in which the Navy plans to conduct sonar training.

Adopting Mitigation Measures of Foreign Nation Navies:

The Navy typically operates in a Strike Group configuration where the group focuses its efforts on conducting air strikes and/or amphibious operations ashore. This requires that the Navy train to what it calls "integrated warfare" meaning that Strike Groups must conduct many different warfare areas simultaneously. These include the ability to defend itself from attacks from submarines, mines, ships, aircraft and missiles. Other nations do not possess the same integrated warfare capabilities as the United States. As a result, many foreign nations' measures are focused solely on reducing what they perceive to be impacts involving ASW. They are not required to locate training areas and position naval forces for the simultaneous and integrated warfare elements that the Navy conducts. As a result, many nations are willing to move training to areas where they believe marine mammals may not exist and do not train in the same bathymetric and littoral environments.

12 MINIMIZATION OF ADVERSE EFFECTS ON SUBSISTENCE USE

Navy training activities in the Gulf of Alaska (GOA) Temporary Maritime Activities Area (TMAA) will not reduce the number of marine mammals available for subsistence use. The TMAA is outside of the normal area of subsistence hunting or harvesting.

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13 MONITORING AND REPORTING MEASURES

A Letter of Instruction, Mitigation Measures Message, or Environmental Annex to the Operational Order, will be issued prior to each exercise to further disseminate the general requirements including mitigation measures and monitoring and reporting procedures necessary during an exercise. The Navy also will continue to fund marine mammal monitoring as part of research goals as outlined in Chapter 14.

13.1 MONITORING PLAN

Navy and the National Marine Fisheries Service (NMFS) will coordinate on the need for development of a monitoring plan specific to the Gulf of Alaska (GOA) Temporary Maritime Activities Area (TMAA). As noted in Section 11.3, prior to implementation of the proposed action for which a letter of authorization is being sought, the Navy will have completed an Integrated Comprehensive Monitoring Program (ICMP). The ICMP will provide the overarching structure and coordination for monitoring efforts Navy-wide. Based on the goals of the monitoring program, the need for GOA specific research objectives and monitoring efforts can be evaluated at that time in coordination with NMFS.

The ICMP will be used both as: (1) a planning tool to focus Navy monitoring priorities (pursuant to Endangered Species Act/Marine Mammal Protection Act [ESA/MMPA] requirements) across Navy Range Complexes and Exercises; and (2) an adaptive management tool, through the consolidation and analysis of the Navy‘s monitoring and watchstander data, as well as new information from other Navy programs (e.g., research and development), and newly published non-Navy information. The ICMP will establish a method (likely an annual review meeting) for NMFS and the Navy to jointly consider prior years monitoring results and advancing science to determine if modifications are needed in mitigation or monitoring measures to better effect the goals laid out in the Mitigation and Monitoring section. The annual review provides potential mechanism for restructuring the monitoring plans and allocating monitoring effort based on the strength of particular specific monitoring proposals that have been developed through the ICMP framework, instead of allocating based on maintaining an equal (or commensurate to effects) distribution of monitoring effort across Range complexes. For example, if careful prioritization and planning through the ICMP shows that a large, intense monitoring effort in a particular location would provide extensive and robust data applicable to assessing the effects of sonar throughout different geographical areas, resources could be focused towards that effort. Alternatively it may be appropriate to have a number of Range Complexes focus resources on similar monitoring efforts so that comparable data could be obtained from a number of locations within a given timeframe.

13.2 REPORTING

The Navy will contact the NMFS Alaska Stranding Coordinator and report any unusual marine mammal behavior and any stranding, beached live/dead or floating marine mammals that may be encountered during Navy training activities.

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14 RESEARCH

The Navy provides a significant amount of funding and support to marine research through a variety of organizations. From fiscal year (FY) 04 to FY 08, the Navy provided over $94 million to universities, research institutions, federal laboratories, private companies, and independent researchers around the world for marine life research. During this same time period, the Department of Defense (DoD) contributed nearly $6 million for a total of $100 million in marine life research projects. These projects include basic science efforts, such as baseline surveys, and do not include monitoring surveys or environmental planning document preparation (DoN 2008c). In FY 08 alone, the Navy will spent over $26 million and the DoD almost $1 million towards this effort (DoN 2008c). Currently, the Navy has budgeted nearly $22 million and the DoD has budgeted a half a million dollars for continued marine mammal research in FY 09 (DoN 2008c). 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, which include the Marine Resources Assessment for the Gulf of Alaska (GOA; DoN 2006). Furthermore, research cruises by the National Marine Fisheries Service (NMFS) and by academic institutions have received funding from the Navy. For instance, the Navy funded the 2009 Gulf of Alaska Line-Transect Survey (GOALS) marine mammal research (Rone et al., 2009) in the TMAA to gather additional information on marine mammal presence and use of that area. 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.

The Navy has also developed the technical reports referenced within this document, which include the GOA Marine Resource Assessment. Furthermore, research cruises by NMFS and by academic institutions have received funding from the Navy. For instance, Navy has funded or contributed funding to marine mammal surveys off southern California, the Marianas Islands, and in the Gulf of Mexico. This research helps in understanding the marine environment and the distribution of marine species and supports Navy's efforts to analyze the effects of training at sea.

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.

A workshop was held in May 2007 at Duke University to discuss the research required to understand the impact of tactical mid-frequency sonar transmission on fish, fisheries and fisheries habitat. Workshop participants included personnel from the Navy, academic universities, and NMFS, who were selected based on their expertise in acoustics, fish hearing and fisheries biology. The objective of the workshop was to describe the range of scientific concerns regarding the effects of Navy training activities using tactical mid-frequency active (MFA) sonar on fish and fisheries resources and to distill these concerns into a long-term research and development plan. The priorities of the workshop included larval fish effects, hearing capabilities, small pelagic and soniferous fish behavior and potential effects to fisheries.

Overall, the Navy will continue to fund ongoing 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.

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APPENDIX A
CETACEAN STRANDING REPORT

A.1 CETACEAN STRANDINGS AND THREATS

Strandings can involve a single animal or several to hundreds of animals. An event where animals are found out of their normal habitat may be considered a stranding even though animals do not necessarily end up beaching (such as the July 2004 "Hanalei Mass Stranding Event"; Southall et al. 2006). Several hypotheses have been given for the mass strandings which include the impact of shallow beach slopes on odontocete echolocation, disease or parasites, geomagnetic anomalies that affect navigation, following a food source in close to shore, avoiding predators, social interactions that cause other cetaceans to come to the aid of stranded animals, and human actions. Generally, inshore species do not strand in large numbers but generally just as individual animals. This may be due to their unfamiliarity with the coastal area. By contrast, pelagic species that are unfamiliar with obstructions or sea bottom tend to strand more often in larger numbers (Woodings 1995). The Navy has studied several stranding events in detail that may have occurred in association with Navy sonar activities. To better understand the causal factors in stranding events that may be associated with Navy sonar activities, the main factors - including bathymetry (i.e. steep drop offs), narrow channels (less than 35 nm), environmental conditions (e.g. surface ducting), and multiple sonar ships (see Section on Stranding Events Associated with Navy Sonar) - were compared among the different stranding events.

A.1.1 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 U.S. is that "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.] section 1421h).

The majority of animals that strand are dead or moribund (NMFS 2007). For animals that strand 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. An event where animals are found out of their normal habitat may be considered a stranding depending on circumstances even though the animals do not necessarily end up beaching (Southall 2006).

Three general categories can be used to describe strandings: single, mass, and unusual mortality events. The most frequent type of stranding 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 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 (71 FR 75234, 2006):

(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.

UMEs are usually unexpected, infrequent, and may involve a significant number of marine mammal mortalities. As discussed below, 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).

A.1.2 United States Stranding Response Organization

Stranding events provide scientists and resource managers 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 amended the MMPA to establish the Marine Mammal Health and Stranding Response Program (MMHSRP) under authority of the NMFS. The MMHSRP was created out of concern started in the 1980s for marine mammal mortalities, to formalize the response process, and to focus efforts being initiated by numerous local stranding organizations and as a result of public concern.

Major elements of the MMHSRP include (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 animal health, and diseased investigation. Currently, 141 organizations are authorized by NMFS to respond to marine mammal strandings (National Marine Fisheries Service 2007o). Through a National Coordinator and six regional coordinators, NMFS authorizes and oversees stranding response activities and provides specialized training for the network.

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 U.S. 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). Nationwide, between 1995-2004, there were approximately 700-1500 cetacean strandings per year and between 2000-4600 pinniped strandings per year (NMFS 2007). In Alaska from 2001-2004, there were 45-165 cetacean strandings per year and 58-125 pinniped strandings per year (NMFS 2007). Detailed regional stranding information including most commonly stranded species can be found in Zimmerman (1991), Geraci and Lounsbury (2005), and NMFS (2007).

A.1.3 Unusual Mortality Events (UMEs)

From 1991 to the present, there have been 45 formally recognized UMEs in the U.S. The UMEs have either involved single or multiple species and dozens to hundreds of individual marine mammals per event (NOAA Fisheries, Office of Protected Resources 2008). Table A-1 contains a list of documented UMEs in and along the Pacific coast of the U.S.

Table A-1. Documented UMEs in the Pacific

Year	Composition	Determination
2007	Guadeloupe fur seals in the Northwest	Cause not determined
2007	Large whales in California	Human Interaction
2007	Cetaceans in California	Cause not determined
2006	Harbor porpoises in the Pacific Northwest	Cause not determined
2006	Sea otters in Alaska	Cause not determined
2003	Sea otters in California	Ecological Factors
2002	Multiple species (common dolphins, California sea lion, sea otters) in California	Biotoxin
2001-2002	Hawaiian monk seals in the Northwest Hawaiian Islands	Ecological Factors
2000	Harbor seals in California	Infectious disease
2000	California sea lions in California	Biotoxin
1999/2000	Gray whales in California, Oregon and Washington	Cause not determined
1998	California sea lions in California	Harmful algal bloom; Domoic acid
1997	Harbor seals in California	Unknown infectious respiratory disease
1994	Common dolphins in California	Cause not determined
1993	Harbor seals, Steller sea lions, and California sea lions on the central Washington coast	Human Interaction
1992-1993	Pinnipeds in California	Ecological Factors
1991	California sea lions in California	Infectious disease

Source: NOAA Fisheries, Office of Protected Resources 2008

Stranding of cetaceans and pinnipeds reported to NMFS Alaska Region from 1998-2007 are summarized in Table A-2. The southcentral area includes the area from Cape Suckling to Cape Douglas and the Kodiak area follows the boundaries of the Kodiak Borough.

Strandings constituting this record were reported by fishermen, hunters, fishery observers, and other members of the public and include animals found dead (floating and beach-cast) and reports of live stranded, mass stranded, abandoned, sick or injured animals. Strandings where the animal(s) could not be examined are included in the numbers as long as the animal was at least identified as either cetacean or pinniped. Human interactions like ship strike/collisions, fishery interactions and entanglements are also included. Known subsistence takes are not included, but suspected subsistence animals are in some cases included (e.g., animals reported shot). Fishery observer reports are not included unless the animal was observed outside of statistical reporting protocols (and thus would not be included by the observer program as part of their watch data set). (NMFS, Alaska Region, Protected Resources 2008).

Both unconfirmed and confirmed reports are included. (NMFS, Alaska Region, Protected Resources 2008). This practice differs somewhat from strandings tabulated in the official record for other regions (such as for the Northwest Region), where a field investigation must confirm the reported stranding, however, Alaska's size, weather conditions, geography, and remote coastlines do not always allow for a field investigation/ confirmation to be a reasonable use of resources.

While the Alaska records could potentially be argued to constitute a variable record based on opportunistic reports, this data collection (sampling) method has been consistent for a decade and therefore constitutes a record that can be compared across reporting years. It is recognized that controls were not established for other important variables influencing the occurrence of strandings and/or the reporting of strandings (e.g, weather, seismic events, changes in fisheries).

Table A-2. Alaska Region Marine Mammal Strandings

Year	Cetacea – All Areas	Beaked Whales – All Areas	Cetacea – Southcentral and Kodiak Areas	Pinnipedia – All Areas	Pinnipedia – Southcentral and Kodiak Areas
1998 – 2002*	110	8	74	50	25
2003	166	1	131	81	14
2004	62	8	33	59	12
2005	63	2	30	54	20
2006	92	1	34	57	26
2007	63	0	30	54	20

Source: NMFS, Alaska Region, Protected Resources 2004; 2005; 2006; 2007; 2008

Records gathered by Zimmerman (1991) for the period between 1975 and 1987 indicate that 325 stranded cetaceans were reported for the entire state of Alaska. Prior to 1985, a centralized Federal stranding network had not been established, which limited the number of stranding reports recorded. Table A-3 details the most commonly stranded cetaceans in the Gulf of Alaska for that period.

Table A-3. Most Commonly Reported Species of Cetaceans Found Stranded in the Gulf of Alaska 1975 – 1987

Species	Number Stranded
Gray Whale	7
Beluga Whale	20
Stejneger's Beaked Whale	5
Killer Whale	6
Cuvier's Beaked Whale	5
Minke Whale	10
Bowhead Whale	0
Humpback Whale	9
Sperm Whale	4
Baird's Beaked Whale	1
Fin Whale	3
Total	70

Source: Zimmerman, 1991

A.1.4 Threats to Marine Mammals and Potential Causes for Stranding

Reports of marine mammal strandings can be traced back to ancient Greece (Walsh et al. 2001). 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 in and of themselves 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 can be blamed 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 potential stranding causes can include both natural and human influenced (anthropogenic) causes listed below and described in the following sections:

Natural Stranding Causes
    Disease
    Natural toxins
    Weather and climatic influences
    Navigation errors
    Social cohesion
    Predation
Human Influenced (Anthropogenic) Stranding Causes
    Fisheries interaction
    Vessel strike
    Pollution and ingestion
    Noise

A.1.4.1 Natural Stranding Causes

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).

Disease

Like other mammals, marine mammals frequently suffer from a variety of diseases of viral, bacterial, parasitic, and fungal origin (Visser et al. 1991, Dunn et al. 2001, Harwood 2002). Gulland and Hall (2005) 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 U.S. 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 marine mammal virus and suppresses a host’s immune system, increasing risk of secondary infection (Harwood 2002). A bottlenose dolphin UME in 1993 and 1994 was caused by infectious disease. Die-offs ranged from northwestern Florida to Texas, with an increased number of deaths as it spread (NMFS 2007c). 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 (a type of morbillivirus) 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, 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 [AS]), 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 AS, 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.

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 although exposure can also occur through inhalation and skin contact (Van Dolah 2005). Figure A-1 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, Bargu et al. 2008, Goldstein et al. 2008). Other algal toxins associated with marine mammal strandings include saxitoxins and ciguatoxins and are summarized by Van Dolah (2005).

Source: Woods Hole Oceanographic Institute (WHO) http://www.whoi.edu/redtide/HABdistribution/HABmap.html

Figure A-1. Animal Mortalities from Harmful Algal Blooms within the U.S., 1997-2006.

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), potential starvation if not successful, and corresponding stranding due directly to starvation or succumbing to disease or predation while in a more weakened, stressed state (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 stranding 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 meridinal 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.

Navigation 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 of the U.S., 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 geometric gradient or 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).

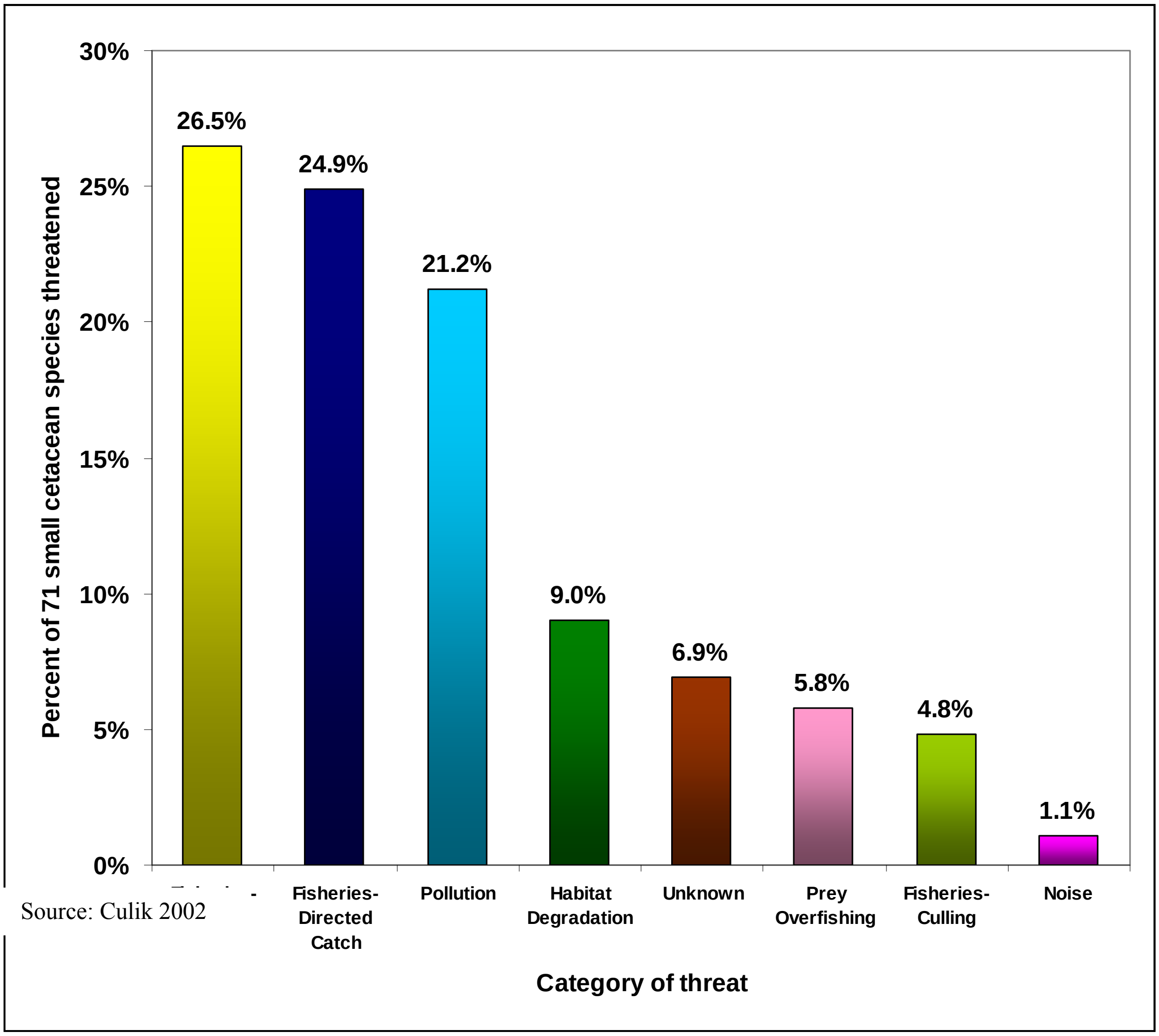
Echolocation Disruption in Shallow Water - Some researchers believe stranding may result from reductions in the effectiveness of echolocation within shallow water, especially with the pelagic species of odontocetes that may be less familiar with coastline (Dudok van Heel 1966, Chambers and James 2005). 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.

Social Cohesion

Many pelagic species such as sperm whale, 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).

A.1.4.2 Anthropogenic Stranding Causes and Potential Risks

With the exception of historic whaling in the 19th and early part of the 20th century, over 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), direct trauma (vessel strikes, gunshots), and noise. Figure A-2 shows potential worldwide risk to small toothed cetaceans by source.



Source: Culik 2002

Figure A-2. Human Threats to World Wide Small Cetacean Populations

Fisheries Interaction: By-Catch, Directed 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 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 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) attempted to estimate the magnitude of marine mammal bycatch in U.S. and global fisheries.

Data on marine mammal bycatch within the United States was obtained from fisheries observer programs, reports of entangled stranded animals, and fishery logbooks, and was then extrapolated to estimate global bycatch by using the ratio of U.S. fishing vessels to the total number of vessels within the world's fleet (Read et al. 2006). Within U.S. fisheries, between 1990 and 1999 the mean annual bycatch of marine mammals was 6,215 animals, with a standard error of +/- 448 (Read et al. 2006). Eight-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, which was significantly lower from 1995-1999 than it was from 1990-1994 (Read et al. 2006). Read et al., (2006) suggests that this is primarily due to effective conservation measures that were implemented during this period.

Read et al. (2006) then extrapolated this data for the same time period and calculated an annual estimate of 653,365 of marine mammals globally, with most of the world's bycatch occurring in gill-net fisheries. With global marine mammal bycatch likely to be in the hundreds of thousands every year, bycatch in fisheries is the single greatest threat to many marine mammal populations around the world (Read et al., 2006).

Entanglement - Entanglement in active fishing gear is a major cause of death or severe injury among the endangered whales in the action area. Entangled marine mammals may die as a result of drowning, escape with pieces of gear still attached to their bodies, manage to be set free either of their own accord, or are set free by fishermen. Many large whales carry off gear after becoming entangled (Read et al. 2006). Many times when a marine mammal swims off with gear attached, the end result can be fatal. The gear may be 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, and the cause of death for many stranded marine mammals is often attributed to such interactions (Baird and Gorgone 2005). Because marine mammals that die or are injured in fisheries may not wash ashore and because not all animals that do wash ashore exhibit clear signs of interactions, stranding data probably underestimate fishery-related mortality and serious injury (NMFS 2005a)

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 2005e). In 1999 it was possible to determine that the cause of death for 38 of the stranded porpoises was from fishery interactions, with one additional animal having been mutilated (right flipper and fluke cut off) (NMFS 2005e). In 2000, one stranded porpoise was found with monofilament line wrapped around its body (NMFS 2005e). In 2003, nine stranded harbor porpoises were attributed to fishery interactions, with an additional three mutilated animals (NMFS 2005e). 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 West Coast of the U.S. (California Marine Mammal Stranding Network Database 2006).

Ship Strike

Vessel strikes to marine mammals are another cause of mortality and stranding (Laist et al. 2001, Geraci and Lounsbury 2005, de Stephanis and Urquiola 2006). An animal at the surface could be struck directly by a vessel, a surfacing animal could hit the bottom of a vessel, or an animal just below the surface could be 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).

An examination of all known ship strikes from all shipping sources (civilian and military) indicates vessel speed is a principal factor in whether a vessel strike results in death (Knowlton and Kraus 2001, Laist et al. 2001, Jensen and Silber 2003, Vanderlaan and Taggart 2007). In assessing records in which vessel speed was known, Laist et al. (2001) found a direct relationship between the occurrence of a whale strike and the speed of the vessel involved in the collision. The authors concluded that most deaths occurred when a vessel was traveling in excess of 13 knots although most vessels do travel greater than 15 knots. Jensen and Silber (2003) detailed 292 records of known or probable ship strikes of all large whale species from 1975 to 2002. Of these, vessel speed at the time of collision was reported for 58 cases. Of these cases, 39 (or 67 percent) resulted in serious injury or death (19 or 33 percent resulted in serious injury as determined by blood in the water, propeller gashes or severed tailstock, and fractured skull, jaw, vertebrae, hemorrhaging, massive bruising or other injuries noted during necropsy and 20 or 35% resulted in death). Operating speeds of vessels that struck various species of large whales ranged from 2 to 51 knots. The majority (79 percent) of these strikes occurred at speeds of 13 knots or greater. The average speed that resulted in serious injury or death was 18.6 knots. Pace and Silber (2005) found that the probability of death or serious injury increased rapidly with increasing vessel speed. Specifically, the predicted probability of serious injury or death increased from 45 percent to 75 % as vessel speed increased from 10 to 14 knots, and exceeded 90% at 17 knots. Higher speeds during collisions result in greater force of impact, but higher speeds also appear to increase the chance of severe injuries or death by pulling whales toward the vessel. Computer simulation modeling showed that hydrodynamic forces pulling whales toward the vessel hull increase with increasing speed (Clyne 1999, Knowlton et al. 1995).

The growth in civilian commercial ports and associated commercial vessel traffic is a result in the globalization of trade. 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 more than 85,000 vessels in 1998 (NRC 2003, Southall 2005). Between 1950 and 1998, the U.S. flagged fleet declined from approximately 25,000 to fewer than 15,000 and currently represents only a small portion of the world fleet. 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. It is unknown how international shipping volumes and densities will continue to grow. However, current statistics support the prediction that the international shipping fleet will continue to grow at the current rate or at greater rates in the future. Shipping densities in specific areas and trends in routing and vessel design are as, or more, significant than the total number of vessels. Densities along existing coastal routes are expected to increase both domestically and internationally. New routes are also 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).

While there are reports and statistics of whales struck by vessels in U.S. waters, the magnitude of the risks of commercial ship traffic poses to marine mammal populations is difficult to quantify or estimate. In addition, there is limited information on vessel strike interactions between ships and marine mammals outside of U.S. waters (de Stephanis and Urquiola 2006). Laist et al. (2001) concluded that ship collisions may have a negligible effect on most marine mammal populations in general, except for regional based small populations where the significance of low numbers of collisions would be greater given smaller populations or populations segments.

U.S. Navy vessel traffic is a small fraction of the overall U.S. commercial and fishing vessel traffic. While U.S. Navy vessel movements may contribute to the ship strike threat, given the lookout and mitigation measures adopted by the U.S. Navy, probability of vessel strikes is greatly reduced. Furthermore, actions to avoid close interaction of U.S. 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. 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.

Commercial and Private Marine Mammal Viewing

In addition to vessel operations, private and commercial vessels engaged in marine mammal watching also have the potential to impact marine mammals in Southern California. NMFS has promulgated regulations at 50 CFR 224.103, which provide specific prohibitions regarding wildlife viewing activities. In addition, NMFS launched an education and outreach campaign to provide commercial operators and the general public with responsible marine mammal viewing guidelines. In January 2002, NMFS also published an official policy on human interactions with wild marine mammals which states: “NOAA Fisheries cannot support, condone, approve or authorize activities that involve closely approaching, interacting or attempting to interact with whales, dolphins, porpoises, seals, or sea lions in the wild. This includes attempting to swim, pet, touch or elicit a reaction from the animals.”

Although considered by many to be a non-consumptive use of marine mammals with economic, recreational, educational, and scientific benefits, marine mammal watching is not without potential negative impacts. One concern is that animals become more vulnerable to vessel strikes once they habituate to vessel traffic (Swingle et al. 1993, Wiley et al. 1995). Another concern is that preferred habitats may be abandoned if disturbance levels are too high. A whale’s behavioral response to whale watching vessels depends on the distance of the vessel from the whale, vessel speed, vessel direction, vessel noise, and the number of vessels (Amaral and Carlson 2005, Au and Green 2000, Cockeron 1995, Erbe 2002, Felix 2001, Magalhaes et al. 2002, Richter et al. 2003, Schedat et al. 2004, Simmonds 2005, Watkins 1986, Williams et al. 2002). The whale’s responses changed with these different variables and, in some circumstances, the whales did not respond to the vessels, but in other circumstances, whales changed their vocalizations surface time, swimming speed, swimming angle or direction, respiration rates, dive times, feeding behavior, and social interactions. In addition to the information on whale watching, there is also direct evidence of pinniped haul out site (Pacific harbor seals) abandonment because of human disturbance at Strawberry Spit in San Francisco Bay (Allen 1991).

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 and can be harmful to wildlife. Not only is debris a hazard because of possible entanglement, animals may mistake plastics and other debris for food (NMFS 2007g). U.S. Navy vessels have a zero-plastic discharge policy and return all plastic waste to appropriate disposition on shore.

There are certain species of cetaceans, along with Florida manatees, that are more likely to eat trash, especially plastics, which is usually fatal for the animal (Geraci et al. 1999). From 1990 through 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 (NMFS 2005a). During the same period, 46 dwarf sperm whale strandings occurred along the U.S. Atlantic coastline between Massachusetts and the Florida Keys (NMFS 2005d). In 1987 a pair of latex examination gloves was retrieved from the stomach of a stranded dwarf sperm whale (NMFS 2005d). One hundred twenty-five pygmy sperm whales were reported stranded from 1999 to 2003 between Maine and Puerto Rico; in one pygmy sperm whale found stranded in 2002, red plastic debris was found in the stomach along with squid beaks (NMFS 2005a).

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 to 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 bio-monitoring 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 to possible adverse health effects in marine mammals. Contaminants such as organochlorines do not tend to accumulate in significant amounts in invertebrates, but do accumulate in fish and fish-eating animals. Thus, contaminant levels in planktivorous mysticetes have been reported to be one to two orders of magnitude lower compared to piscivorous odontocetes (Borell 1993, O'Shea and Brownell 1994, O'Hara and Rice 1996, O'Hara et al. 1999).

The manmade chemical PCB (polychlorinated biphenyl), and the pesticide DDT (dichlorodiphyenyltrichloroethane), 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 (NMFS 2007c). Both compounds are long-lasting, reside in marine mammal fat tissues (especially in the blubber), and can be toxic causing effects such as reproductive impairment and immunosuppression (NMFS 2007c).

Both long-finned and short-finned pilot whales have a tendency to mass strand throughout their range. Short-finned pilot whales have been reported as stranded as far north as Rhode Island, and long-finned pilot whales as far south as South Carolina (NMFS 2005b). For U.S. East Coast stranding records, both species are lumped together and there is rarely a distinction between the two because of uncertainty in species identification (NMFS 2005b). Since 1980 within the Northeast region alone, between 2 and 120 pilot whales have stranded annually either individually or in groups (NMFS 2005b). Between 1999 and 2003 from Maine to Florida, 126 pilot whales were reported stranded, including a mass stranding of 11 animals in 2000 and another mass stranding of 57 animals in 2002, both along the Massachusetts coast (NMFS 2005b).

It is unclear how much of a role human activities play in these pilot whale strandings, and toxic poisoning may be a potential human-caused source of mortality for pilot whales (NMFS 2005b). Moderate levels of PCBs and chlorinated pesticides (such as DDT, DDE, and dieldrin) have been found in pilot whale blubber (NMFS 2005b). Bioaccumulation levels have been found to be more similar in whales from the same stranding event than from animals of the same age or sex (NMFS 2005b). Numerous studies have measured high levels of toxic metals (mercury, lead, and cadmium), selenium, and PCBs in pilot whales in the Faroe Islands (NMFS 2005b). Population effects resulting from such high contamination levels are currently unknown (NMFS 2005b).

Habitat contamination and degradation may also play a role in marine mammal mortality and strandings. Some events caused by man have direct and obvious effects on marine mammals, such as oil spills (Geraci et al. 1999). But in most cases, effects of contamination will more than likely be indirect in nature, such as effects on prey species availability, or by increasing disease susceptibility (Geraci et al. 1999).

U.S. Navy vessel operation between ports and exercise locations has the potential for release of small amounts of pollutant discharges into the water column. U.S. 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.

Deep Water Ambient Noise

Urick (1983) provided a discussion of the ambient noise spectrum expected in the deep ocean. Shipping, seismic activity, and weather, are the primary causes of deep-water ambient noise. The ambient noise frequency spectrum can be predicted fairly accurately for most deep-water areas based primarily on known shipping traffic density and wind state (wind speed, Beaufort wind force, or sea state) (Urick 1983). For example, for frequencies between 100 and 500 Hz, Urick (1983) estimated the average deep water ambient noise spectra to be 73 to 80 dB for areas of heavy shipping traffic and high sea states, and 46 to 58 dB for light shipping and calm seas.

Shallow Water Ambient Noise

In contrast to deep water, ambient noise levels in shallow waters (i.e., coastal areas, bays, harbors, etc.) are subject to wide variations in level and frequency depending on time and location. The primary sources of noise include distant shipping and industrial activities, wind and waves, marine animals (Urick 1983). At any give time and place, the ambient noise is a mixture of all of these noise variables. In addition, sound propagation is also affected by the variable shallow water conditions, including the depth, bottom slope, and type of bottom. Where the bottom is reflective, the sounds levels tend to be higher, than when the bottom is absorptive.

Noise from Aircraft and Vessel Movement

Surface shipping is the most widespread source of anthropogenic, low frequency (0 to 1,000 Hz) noise in the oceans and may contribute to over 75 percent of all human sound in the sea (Simmonds and Hutchinson 1996, ICES 2005b). Ross (1976) has estimated that between 1950 and 1975, shipping had caused a rise in ambient noise levels of 10 dB. He predicted that this would increase by another 5 dB by the beginning of the 21st century. The National Resource Council (1997) estimated that the background ocean noise level at 100 Hz has been increasing by about 1.5 dB per decade since the advent of propeller-driven ships. Michel et al. (2001) suggested an association between long-term exposure to low frequency sounds from shipping and an increased incidence of marine mammal mortalities caused by collisions with ships.

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 operations, 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 or swim away from the aircraft track.

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 2000). 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 emission into the marine environment. Propeller-driven vessels also generate noise through cavitation, which accounts for 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.

Whales have variable responses to vessel presence or approaches, ranging from apparent tolerance to diving away. Unfortunately, it is not always possible to determine whether the whales are responding to the vessel itself or the noise generated by the engine and cavitation around the propeller. Apart from some disruption of behavior, an animal may be unable to hear other sounds in the environment due to masking by the noise from the vessel. Any masking of environmental sounds or conspecific sounds is expected to be temporary, as noise dissipates with a vessel transit through an area.

Vessel noise primarily raises concerns for masking of environmental and conspecific cues. However, exposure to vessel noise of sufficient intensity and/or duration can also result in temporary or permanent loss of sensitivity at a given frequency range, referred to as temporary or permanent threshold shifts (TTS or PTS). Threshold shifts are assumed to be possible in marine mammal species as a result of prolonged exposure to large vessel traffic noise due to its intensity, broad geographic range of effectiveness, and constancy.

Collectively, significant cumulative exposure to individuals, groups, or populations can occur if they exhibit site fidelity to a particular area; for example, whales that seasonally travel to a regular area to forage or breed may be more vulnerable to noise from large vessels compared to transiting whales. Any permanent threshold shift in a marine animal’s hearing capability, especially at particular frequencies for which it can normally hear best, can impair its ability to perceive threats, including ships. Whales have variable responses to vessel presence or approaches, ranging from apparent tolerance to diving away from a vessel. It is not possible to determine whether the whales are responding to the vessel itself or the noise generated by the engine and cavitation around the propeller. Apart from some disruption of behavior, an animal may be unable to hear other sounds in the environment due to masking by the noise from the vessel.

Most observations of behavioral responses of marine mammals to human generated sounds have been limited to short-term behavioral responses, which included the cessation of feeding, resting, or social interactions. Nowacek et al. (2007) provide a detailed summary of cetacean response to underwater noise.

Given the sound 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). U.S. Navy vessels, however, have incorporated significant underwater ship quieting technology to reduce their acoustic signature (compared to a similarly sized vessel) in order to reduce their vulnerability to detection by enemy passive acoustics (Southall 2005). Therefore, the potential for TTS or PTS from U.S. Navy vessel and aircraft movement is extremely low given that the exercises and training events are transitory in time, with vessels moving over large area of the ocean. A marine mammal or sea turtle is unlikely to be exposed long enough at high levels for TTS or PTS to occur. Any masking of environmental sounds or conspecific sounds is expected to be temporary, as noise dissipates with a U.S. Navy vessel transiting through an area. If behavioral disruptions result from the presence of aircraft or vessels, it is expected to be temporary. Animals are expected to resume their migration, feeding, or other behaviors without any threat to their survival or reproduction. However, if an animal is aware of a vessel and dives or swims away, it may successfully avoid being struck.

A.1.5 Stranding Events Associated with Navy Sonar

There are two classes of sonars employed by the U.S. Navy: active sonars and passive sonars. 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 (ICES 2005b).

The effects of mid-frequency active naval sonar on marine wildlife have not been studied as extensively as the effects of air-guns used in seismic surveys (Madsen et al. 2006, Stone and Tasker 2006, Wilson et al. 2006, Palka and Johnson 2007, Parente et al. 2007). Maybaum (1989, 1993) observed changes in behavior of humpbacks during playback tapes of the M-1002 system (using 203 dB re 1 μPa-m for study); specifically, a decrease in respiration, submergence, and aerial behavior rates; and an increase in speed of travel and track linearity. Direct comparison of Maybaum's results, however, with U.S Navy mid-frequency active sonar are difficult to make. Maybaum's signal source, the commercial M-1002, operated differently from naval mid-frequency sonar. In addition, behavioral responses were observed during playbacks of a control tape, (i.e. a tape with no sound signal) so interpretation of Maybaum's results are inconclusive.

Research by Nowacek, et al. (2004) on North Atlantic right whales using a whale alerting signal designed to alert whales to human presence suggests that received sound levels of only 133 to 148 pressure level (decibel [dB] re 1 microPascals [μPa]) for the duration of the sound exposure may disrupt feeding behavior. The authors did note, however, that within minutes of cessation of the source, a return to normal behavior would be expected. Direct comparison of the Nowacek et al. (2004) sound source to MFA sonar, however, is not possible given the radically different nature of the two sources. Nowacek et al.'s source was a series of non-sonar like sounds designed to purposely alert the whale, lasting several minutes, and covering a broad frequency band. Direct differences between Nowacek et al. (2004) and MFA sonar is summarized below from Nowacek et al. (2004) and Nowacek et al. (2007):

(1) Signal duration: Time difference between the two signals is significant, 18-minute signal used by Nowacek et al. versus < 1 sec for MFA sonar.

(2) Frequency modulation: Nowacek et al. contained three distinct signals containing frequency modulated sounds:

1st - alternating 1-sec pure tone at 500 and 850 Hz

2nd - 2-sec logarithmic down-sweep from 4500 to 500 Hz

3rd - pair of low-high (1500 and 2000 Hz) sine wave tones amplitude modulated at 120 Hz

(3) Signal-to-noise ratio: Nowacek et al.'s signal maximized signal-to noise-ratio so that it would be distinct from ambient noise and resist masking.

(4) Signal acoustic characteristics: Nowacek et al.'s signal comprised of disharmonic signals spanning northern right whales' estimated hearing range.

Given these differences, therefore, the exact cause of apparent right whale behavior noted by the authors can not be attributed to any one component since the source was such a mix of signal types.

The effects of naval sonars on marine wildlife have not been studied as extensively as have the effects of airguns used in seismic surveys (Nowacek et al., 2007). In the Caribbean, sperm whales were observed to interrupt their activities by stopping echolocation and leaving the area in the presence of underwater sounds surmised to have originated from submarine sonar signals (Watkins and Schevill 1975, Watkins et al. 1985). The authors did not report receive levels from these exposures, and also got a similar reaction from artificial noise they generated by banging on their boat hull. It was unclear if the sperm whales were reacting to the sonar signal itself or to a potentially new unknown sound in general. Madsen et al. (2006) tagged and monitored eight sperm whales in the Gulf of Mexico exposed to seismic airgun surveys. Sound sources were from approximately 2 to 7 nm (4 to 13 km) away from the whales and based on multipath propagation RLs were as high as 162 dB re 1 uPa with energy content greatest between 0.3 and 3.0 kHz. Sperm whales engaged in foraging dives continued the foraging dives throughout exposures to these seismic pulses. In the Caribbean Sea, sperm whales avoided exposure to mid-frequency submarine sonar pulses, in the range 1000 Hz to 10,000 Hz (IWC 2005). Sperm whales have also moved out of areas after the start of air gun seismic testing (Davis et al. 1995). In contrast, during playback experiments off the Canary Islands, André et al. (1997) reported that foraging sperm whales exposed to a 10 kHz pulsed signal did not exhibit any general avoidance reactions.

The Navy sponsored tests of the effects of low-frequency active (LFA) sonar source, between 100 Hz and 1000 Hz, on blue, fin, and humpback whales. The tests demonstrated that whales exposed to sound levels up to 155 dB did not exhibit significant disturbance reactions, though there was evidence that humpback whales altered their vocalization patterns in reaction to the noise. Given that the source level of the Navy's LFA is reported to be in excess of 215 dB, the possibility exists that animals in the wild may be exposed to sound levels much higher than 155 dB.

Acoustic exposures have been demonstrated to kill marine mammals and result in physical trauma, and injury (Ketten 2005). Animals in or near an intense noise source can die from profound injuries related to shock wave or blast effects. Acoustic exposures can also result in noise induced hearing loss that is a function of the interactions of three factors: sensitivity, intensity, and frequency. Loss of sensitivity is referred to as a threshold shift; the extent and duration of a threshold shift depends on a combination of several acoustic features and is specific to particular species (TTS or PTS, depending on how the frequency, intensity and duration of the exposure combine to produce damage). In addition to direct physiological effects, noise exposures can impair an animal's sensory abilities (masking) or result in behavioral responses such as aversion or attraction (see Section 3.19).

Acoustic exposures can also result in the death of an animal by impairing its foraging, ability to detect predators or communicate, or by increasing stress, and disrupting important physiological events. Whales have moved away from their feeding and mating grounds (Bryant et al. 1984, Morton and Symnods 2002, Weller et al. 2002), moved away from their migration route (Richardson et al. 1995), and have changed their calls due to noise (Miller et al. 2000). Acoustic exposures such as MFA sonar tend to be infrequent and temporary in nature. In situations such as the alteration of gray whale migration routes in response to shipping and whale watching boats, those acoustic exposures were chronic over several years (Moore and Clarke 2002). This was also true of the effect of seismic survey airguns (daily for 39 days) on the use of feeding areas by gray whales in the western North Pacific although whales began returning to the feeding area within one day of the end of the exposure (Weller et al. 2002).

Below are evaluations of the general information available on the variety of ways in which cetaceans and pinnipeds have been reported to respond to sound, generally, and mid-frequency sonar, in particular.

The Navy is very concerned and coordinates with NMFS as they thoroughly investigate each marine mammal stranding potentially associated with Navy activities to better understand the events surrounding strandings (Norman 2006). Strandings can involve a single animal or several to hundreds. An event where animals are found out of their normal habitat may be considered a stranding even though animals do not necessarily end up beaching (such as the July 2004 "Hanalei Mass Stranding Event"; Southall et al. 2006). Several hypotheses have been given for the mass strandings which include the impact of shallow beach slopes on odontocete sonar, disease or parasites, geomagnetic anomalies that affect navigation, following a food source in close to shore, avoiding predators, social interactions that cause other cetaceans to come to the aid of stranded animals, and human actions. Generally, inshore species do not strand in large numbers but generally just as a single animal. This may be due to their familiarity with the coastal area whereas pelagic species that are unfamiliar with obstructions or sea bottom tend to strand more often in larger numbers (Woodings 1995). The Navy has studied several stranding events in detail that may have occurred in association with Navy sonar activities. To better understand the causal factors in stranding events that may be associated with Navy sonar activities, the main factors, including bathymetry (i.e., steep drop offs), narrow channels (less than 35 nm), environmental conditions (e.g., surface ducting), and multiple sonar ships were compared between the different stranding events.

When a marine mammal swims or floats onto shore and becomes “beached” or stuck in shallow water, it is considered a “stranding” (MMPA section 410 (16 USC section 1421g); NMFS 2007a). NMFS explains that “a cetacean is considered stranded when it is on the beach, dead or alive, or in need of medical attention while free-swimming in U.S. waters. A pinniped is considered to be stranded either when dead or when in distress on the beach and not displaying normal haul-out behavior” (NMFS 2007b).

Over the past three decades, several “mass stranding” events [strandings involving two or more individuals of the same species (excluding a single cow-calf pair) and at times, individuals from different species] that have occurred have been associated with naval operations, seismic surveys, and other anthropogenic activities that introduce sound into the marine environment (Canary Islands, Greece, Vieques, U.S. Virgin Islands, Madeira Islands, Haro Strait, Washington State, Alaska, Hawaii, North Carolina).

Information was collected on mass stranding events (events in which two or more cetaceans stranded) that have occurred and for which reports are available, from the past 40 years. Any causal agents that have been associated with those stranding events were also identified. Major range events undergo name changes over the years, however, the equivalent of COMPTUEX and JTFEX have been conducted in southern California since 1934. Training involving sonar has been conducted since World War II and sonar systems described in the SOCAL EIS/OEIS since the 1970's (Jane’s 2005).

A.1.6 Stranding Analysis

Over the past two decades, several mass stranding events involving beaked whales have been documented. While beaked whale strandings have been reported since the 1800s (Geraci and Lounsbury 1993, Cox et al. 2006, Podesta et al. 2006), several mass strandings since have been associated with naval operations that may have included mid-frequency sonar (Simmonds and Lopez-Jurado 1991, Frantzis 1998, Jepson et al. 2003, Cox et al. 2006). As Cox et al. (2006) concludes, the state of science can not yet determine if a sound source such as mid-frequency sonar alone causes beaked whale strandings, or if other factors (acoustic, biological, or environmental) must co-occur in conjunction with a sound source.

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).

The discussion below centers on those worldwide stranding events that may have some association with naval operations, and global strandings that the U.S. Navy feels are either inconclusive or can not be associated with naval operations.

A.1.6.1 Naval Association

In the following sections, specific stranding events that have been putatively linked to potential sonar operations are discussed. Of note, these events represent a small 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 U.S. Navy presence was limited (Greece, Portugal, Spain). One of the five events involved only U.S. Navy ships (Bahamas).

Beaked whale stranding events associated with potential naval operations.

1996 May	Greece (NATO)
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)

Case Studies of Stranding Events (coincidental with or implicated with naval sonar)

1996 Greece Beaked Whale Mass Stranding (May 12 – 13, 1996)

Description: Twelve Cuvier's beaked whales (*Ziphius cavirostris*) stranded along a 38.2-kilometer 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: 1µPa, 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 cephalopods 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 - Cuvier's beaked whales, Blainville's beaked whales (*Mesoplodon densirostris*), minke whale (*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 U.S. Navy 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 animals (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: 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.

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.

Conclusions: The post-mortem analyses of stranded beaked whales lead to the conclusion that the immediate cause of death resulted from overheating, cardiovascular collapse and stresses associated with being stranded on land. However, 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. Baleen whale stranding events have not been associated with either low-frequency or mid-frequency sonar use (ICES 2005a, 2005b).

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 to 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 to 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 (September 24, 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 (Neo-Tapon 2002) that involved 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 on 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 the 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 brief 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 long enough 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. Tyack et al. (2006) showed that beaked whales often make rapid ascents from deep dives suggesting that it is unlikely that beaked whales would suffer from decompression sickness. Zimmer and Tyack (2007) speculated that if repetitive shallow dives that are used by beaked whales to avoid a predator or a sound source, they could accumulate high levels of nitrogen because they would be above the depth of lung collapse (above about 210 feet) and could lead to decompression sickness. There is no evidence that beaked whales dive in this manner in response to predators or sound sources and other marine mammals such as Antarctic and Galapagos fur seals, and pantropical spotted dolphins make repetitive shallow dives with no apparent decompression sickness (Kooyman and Trillmich 1984, Kooyman et al. 1984, Baird et al. 2001).

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). Moore and Early (2004) reported that in analysis of sperm whale bones spanning 111 years, gas embolism symptoms were observed indicating that sperm whales may be susceptible to decompression sickness due to natural diving behavior. 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 agreed to adopt 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 to 28, 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 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 January 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 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 1000 meters in depth near a shoreline where there is a rapid change in bathymetry on the order of 1000 to 6000 meters 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 (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).

A.1.6.2 Other Global Stranding Discussions

In the following sections, stranding events that have been linked to U.S. Navy activity in popular press are presented. As detailed in the individual case study conclusions, the U.S. Navy believes there is enough evidence available to refute allegations of impacts from mid-frequency sonar, or at least indicate a substantial degree of uncertainty in time and space that precludes a meaningful scientific conclusion.

Case Studies of Stranding Events

2003 Washington State Harbor Porpoise Strandings (May 2 – June 2, 2003)

Description: At 1040 hours on May 5, 2003, the USS SHOUP began the use of mid-frequency tactical active sonar as part of a naval exercise. At 1420, the USS SHOUP entered the Haro Strait and terminated active sonar use at 1438, 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 U.S. Department of Navy (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.

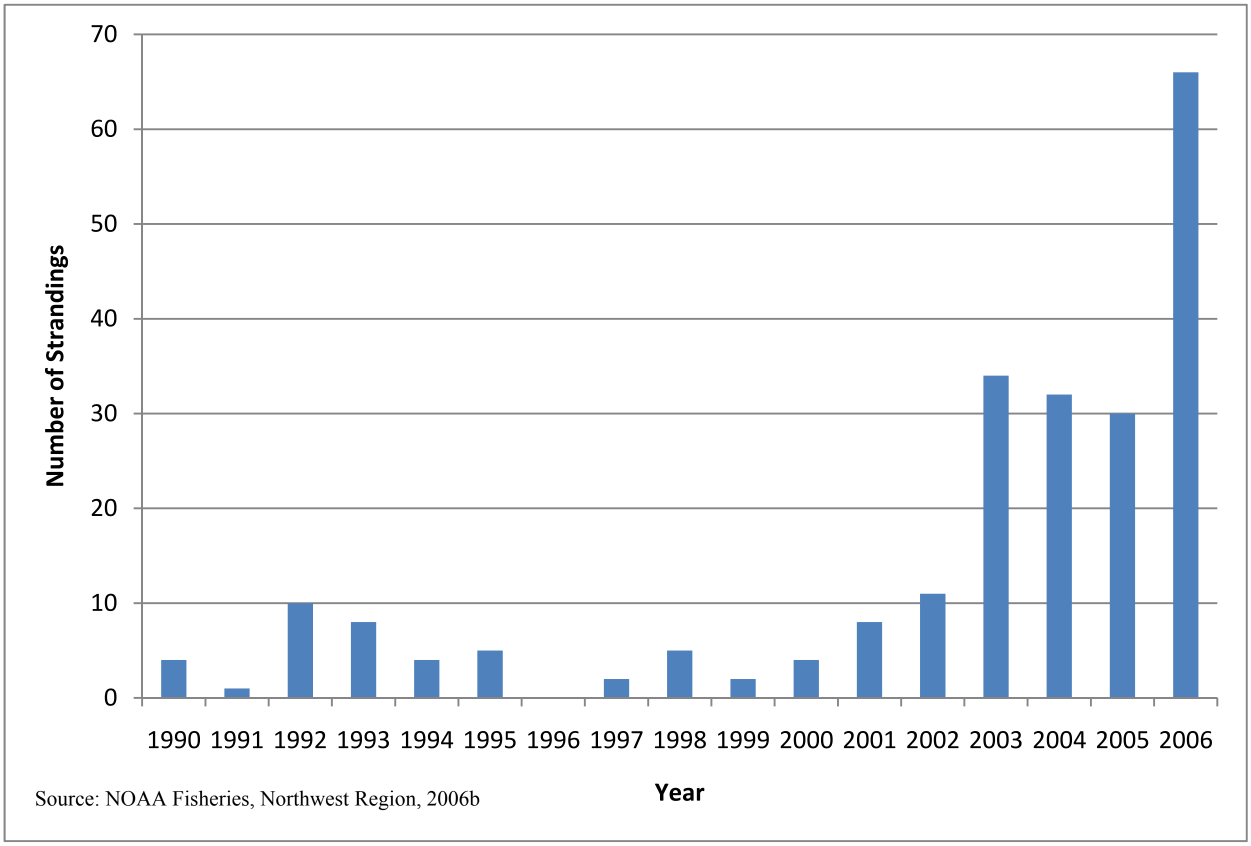
Whole carcasses of ten harbor porpoises and the head of an additional porpoise were collected for analysis. Necropsies were performed on ten of the porpoises and six whole carcasses, and two heads were selected for CT imaging. Gross examination, histopathology, age determination, blubber analysis, and 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. It is important to note, however, that these determinations were based only on the evidence from the necropsy to avoid bias with regard to determinations of the potential presence or absence of acoustic trauma. The result was that other potential causal factors, such as one animal (Specimen 33NWR05005) found tangled in a fishing net, was unknown to the investigators in their determination regarding the likely cause of death.

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). In this regard, 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 phenomena 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, most likely, to be 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.

Additionally, it has become clear that the number of harbor porpoise strandings in the Northwest increased beginning in 2003 and through 2006. Figure A-3 shows the number of strandings documented in the Northwest for harbor porpoises. On November 3, 2006, a UME in the Pacific Northwest was declared. In 2006, a total of 66 harbor porpoise strandings were reported in the Outer Coast of Oregon and Washington and Inland waters of Washington (NOAA Fisheries 2006, NOAA Fisheries, Northwest Region 2006a).



Source: NOAA Fisheries, Northwest Region, 2006b

Figure A-3. Northwest Region Harbor Porpoise Strandings 1990 - 2006

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.

Additional allegations regarding USS SHOUP use of sonar having caused behavioral effects to Dall's porpoise, orca, and a minke whale also arose in association with this event (see U.S. Department of Navy 2004 for a complete discussion).

Dall's porpoise: Information regarding the observation of Dall's porpoise on May 5, 2003 came from the operator of a whale watch boat at an unspecified location. This operator reported the Dall's porpoise were seen "going north" when the SHOUP was estimated by him to be 10 miles away. Potential reasons for the Dall's movement include the pursuit of prey, the presence of harassing resident orca or predatory transient orca, vessel disturbance from one of many whale watch vessels, or multiple other unknowable reasons including the use of sonar by SHOUP. In short, there was nothing unusual in the observed behavior of the

Dall's porpoise on May 5, 2003 and no way to assess if the otherwise normal behavior was in reaction to the use of sonar by USS SHOUP, any other potential causal factor or a combination of factors.

Orca: Observer opinions regarding orca J-Pod behaviors on 5 May 2003 were inconsistent, ranging from the orca being "at ease with the sound" or "resting" to their being "annoyed." One witness reported observing "low rates of surface active behavior" on behalf of the orca J-Pod, which is in conflict with that of another observer who reported variable surface activity, tail slapping and spyhopping. Witnesses also expressed the opinion that the behaviors displayed by the orca on 5 May 2003 were "extremely unusual," although those same behaviors are observed and reported regularly on the Orca Network Website, are behaviors listed in general references as being part of the normal repertoire of orca behaviors. Given the contradictory nature of the reports on the observed behavior of the J-Pod orca, there is no way to assess if any unusual behaviors were present or if present they were in reaction to vessel disturbance from one of many nearby whale watch vessels, use of sonar by SHOUP, any other potential causal factor, or a combination of factors.

Minke whale: A minke whale was reported porpoising in Haro Strait on May 5, 2003, which is a rarely observed behavior. The cause of this behavior is indeterminate given multiple potential causal factors including but not limited to the presence of predatory Transient orca, possible interaction with whale watch boats, other vessels, or SHOUP's use of sonar. Given the existing information, there is no way to be certain if the unusual behavior observed was in reaction to the use of sonar by SHOUP, any other potential causal factor or a combination of factors.

2004 Alaska Beaked Whale Strandings (Northern Edge Exercise, 7-16 June 2004)

Description: Between 27 June and 19 July 2004, five beaked whales were discovered at various locations along 1,600 miles of the Alaskan coastline and one was found floating (dead) at sea. These whales included three Baird's beaked whales and two Cuvier's beaked whales. Questions and comments posed on previous Navy environmental documents have alleged that sonar use may have been the cause of these strandings in association with the Navy Alaska Shield/Northern Edge exercise, which occurred June 7 to June 16, 2004 (within the approximate timeframe of these strandings).

Findings: Information regarding the strandings is incomplete as the whales had been dead for some time before they were discovered. The stranded beaked whales were in moderate to advanced states of decomposition and necropsies were not performed. Additionally, prior to the Navy conducting the Alaska Shield/Northern Edge exercise, two Cuvier's beaked whales were discovered stranded at two separate locations along the Alaskan coastline (February 26 at Yakutat and June 1 at Nuka Bay).

Zimmerman (1991) reported that between 1975 and 1987, 11 species of cetaceans were found stranded in Alaska seven or more times, including 29 Stejneger's beaked whales, 19 Cuvier's beaked whales, and 8 Baird's beaked whales. Cuvier's beaked whales have been found stranded from the eastern Gulf of Alaska to the western Aleutians. Baird's beaked whales were found stranded as far north as the area between Cape Pierce and Cape Newenham, east near Kodiak, and along the Aleutian Islands. (Zimmerman 1991). In short, however, the stranding of beaked whales in Alaska is a relatively uncommon occurrence (as compared to other species).

Conclusions: The at-sea portion of the Alaska Shield/Northern Edge 2004 exercise consisted mainly surface ships and aircraft tracking a vessel of interest 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 or been related to any of the strandings over this 33 day period along 1,600 miles of coastline.

2004 Hawai'i Melon-Headed Whale Unusual Milling Event (July 3-4 2004)

Description: The majority of the following information is taken from the NMFS report (which referred to the event as a "mass stranding event"; Southall et al. 2006) but includes additional and new information not presented in the NMFS report. On the morning of July 3, 2004, between 150 and 200 melon-headed whales (*Peponocephala electra*) entered Hanalei Bay, Kauai. Individuals attending a canoe blessing ceremony observed the animals entering the bay at approximately 7:00 a.m. The whales were reported entering the bay in a "wave as if they were chasing fish" (Braun 2006). At 6:45 a.m. on July 3, 2004, approximately 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. The Navy believes that the abnormal behavior by the whales during this time is likely the result of people and boats in the water with the whales rather than the result of sonar activities taking place 25 or more miles off the coast. 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 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 700-to-800-foot 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 unusual milling event, NMFS undertook an investigation of possible causative factors of the event. 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 1.4-4.0 m/s for 6.5 to 17.5 hours after sonar transmissions ceased to reach Hanalei Bay by 7:00 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 138-149 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 2007). One of the first observations of the whales entering the bay reported the pod came into the bay in a line "as if chasing fish" (Braun 2005). In addition, a group of 500 to700 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, possibly 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.

Conclusions: 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 exists that 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 adults may maintain a swim speed of 4.0 m/s for some time, 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 training range have been used in RIMPAC exercises for more than 30 years, and are used year-round for ASW training with 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. 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 1.5 to 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 have caused the 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 (Mobley et al. 2007). 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 event 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 event highly speculative at best.

1980- 2004 Beaked Whale Strandings in Japan (Brownell et al. 2004)

<u>Description</u>: Brownell et al. (2004) compare 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 the US. 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 those stranding dates.

To fully investigate the allegation made by Brownell et al. (2004), the Center for Naval Analysis (CNA) in an internal Navy report, looked at 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 soon (within weeks) after any U.S. Navy exercises. While the CNA analysis began by investigating the probabilistic nature of any co-occurrences, the strandings and sonar use were not correlated by time. Given that there was no instance of co-occurrence in over 20 years of stranding data, it can be reasonably postulated that sonar use in Japan waters by U.S. Navy vessels did not lead to any of the strandings documented by Brownell et al. (2004).

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 area from Cape Hatteras northward. Because of the live stranding of multiple species, the event was classified as a UME. 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 U.S. Navy indicated that from January 12-14 some unit level training with mid-frequency active sonar was conducted by vessels that were 93 to 185 km 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 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. 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 the 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.

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 occasionally 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, if not likely, contributing factor to the North Carolina UME of January 15. 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).

A.1.6.3 Causal Associations for Stranding Events

Several stranding events have been associated with Navy sonar activities but relatively few of the total stranding events that have been recorded occurred spatially or temporally with Navy sonar activities. While sonar may be a contributing factor under certain rare conditions, the presence of sonar it is not a necessary condition for stranding events to occur. In established range areas such as those in Hawaii and Southern California where sonar use has been routine for decades, there is no evidence of impacts from sonar use on marine mammals.

A review of past stranding events associated with sonar suggest that the potential factors that may contribute to a stranding event are steep bathymetry changes, narrow channels, multiple sonar ships, surface ducting and the presence of beaked whales that may be more susceptible to sonar exposures. The most important factors appear to be the presence of a narrow channel (e.g. Bahamas and Madeira Island, Portugal) that may prevent animals from avoiding sonar exposure and multiple sonar ships within that channel. There are no narrow channels (less than 35 nm wide and 10 nm in length) in the MAA and the ships would be spread out over a wider area allowing animals to move away from sonar activities if they choose. In addition, beaked whales may not be more susceptible to sonar but may favor habitats that are more conducive to sonar effects. There have been no mass strandings in GOA attributed to Navy sonar during any of the prior Northern Edge exercises or as the result of ay Navy sonar use.

A.1.7 Stranding Section Conclusions

Marine mammal strandings have been a historic and ongoing occurrence attributed to a variety of causes. Over the last 50 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.

By comparison and as described previously, potential impacts to all species of cetaceans worldwide from fishery related mortality can be orders of magnitude more significant (100,000s of animals versus tens of animals) (Culik 2002, ICES 2005b, Read et al. 2006). This does not negate the influence of any mortality or additional stressor to small, regionalized sub-populations which may be at greater risk from human related mortalities (fishing, vessel strike, sound) than populations with larger oceanic level distribution or migrations. ICES (2005a) noted, however, that taken in context of marine mammal populations in general, sonar is not a major threat, nor is it a significant portion of the overall ocean noise budget.

In conclusion, a constructive framework and 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. 2005, ICES 2005b, Barlow and Gisiner 2006, Cox et al. 2006).

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APPENDIX B
MARINE MAMMAL IMPACT ANALYSIS METHODS

Part 1—General Description

B.1 BACKGROUND AND OVERVIEW

All marine mammals are protected under the Marine Mammal Protection Act (MMPA). The MMPA prohibits, with certain exceptions, the unauthorized 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 U.S.

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 the MMPA, listed as either endangered or threatened under the 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 the MMPA and 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.

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 immitigable 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 primary potential impact to marine mammals from underwater acoustics is Level B harassment from exposure to various sources of sound in the water including sonar and explosives. The criteria for modeling impacts from these sources are detailed in the following sections.

B.1.1 Acoustic Sound Sources

The amount of Threshold Shift depends on the amplitude, duration, frequency, and temporal pattern of the sound exposure. Threshold shifts will generally increase with the amplitude and duration of sound exposure. For continuous sounds, exposures of equal energy will lead to approximately equal effects (Ward 1997). For intermittent sounds, less Threshold Shift will occur than from a continuous exposure with the same energy (some recovery will occur between exposures) (Kryter et al. 1966, Ward 1997). The magnitude of Threshold Shift normally decreases with the amount of time post-exposure (Miller 1974).

Permanent Threshold Shift (PTS) is non-recoverable and results from the destruction of tissues within the auditory system. PTS therefore qualifies as an injury and is classified as Level A harassment under the MMPA. The smallest amount of PTS (onset-PTS) is taken to be the indicator for the smallest degree of injury that can be measured. The acoustic exposure associated with onset-PTS is used to define the outer limit of the Level A exposure zone.

If the TS eventually returns to zero (the threshold returns to the pre-exposure value), the TS is a Temporary Threshold Shift (TTS). TTS is, from recent rulings (NOAA 2001, 2002a), considered to result from the temporary, non-injurious distortion of hearing-related tissues. The smallest measurable amount of TTS (onset-TTS) is taken as the best indicator for slight temporary sensory impairment. Because it is considered non-injurious, the acoustic exposure associated with onset-TTS is used to define the outer limit of the portion of the Level B exposure zone attributable to physiological effects. This follows from the concept that hearing loss potentially affects an animal’s ability to react normally to the sounds around it. Therefore, the potential for TTS is considered as Level B harassment caused by physiological effects on the auditory system.

The exposure threshold established for onset-TTS is 195 dB re 1μPa^2-s. This result is supported by the short-duration tone data of Finneran et al. (2002, 2005) and the long-duration sound data from Nachtigall et al. (2003). 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 1μPa^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 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 increase from onset-TTS) for analysis, the PTS threshold for cetacea is 215 dB re 1μPa^2-s.

Unlike cetaceans, the TTS and PTS thresholds used for pinnipeds vary with species. Otariids have thresholds of 206 dB re 1μPa^2-s for TTS and 226 dB re 1μPa^2-s for PTS. Northern elephant seals are similar to otariids (TTS = 204 dB re 1μPa^2-s, PTS = 224 dB re 1μPa^2-s) but are lower for harbor seals

(TTS = 183 dB re 1µPa^2-s, PTS = 203 dB re 1µPa^2-s). A certain proportion of marine mammals is expected to experience behavioral disturbance at different received sound pressure levels and are counted as Level B harassment takes. The details of this theory and calculation are described in the Risk Function section. Table B-1 summarizes the threshold levels for analysis of non-explosive sound sources used during Navy training activities in the Gulf of Alaska (GOA) Temporary Maritime Activities Area (TMAA).

Table B-1 – Non-Explosive Sound Source Threshold Levels

Physiological Effects			
Animal	**Criteria**	**Threshold (re 1µPa^2-s)**	**MMPA Effect**
Cetacean	TTS PTS	195 215	Level B Harassment Level A Harassment
Pinnipeds			
Northern Elephant Seal	TTS PTS	204 224	Level B Harassment Level A Harassment
Steller Sea Lion	TTS PTS	206 226	Level B Harassment Level A Harassment
Northern Fur Seal	TTS PTS	206 226	Level B Harassment Level A Harassment

B.1.2 Explosives

For underwater explosions resulting from use of live ordnance in the TMAA, 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 sound and pressure impacts from underwater explosions 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.

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 1µPa^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.

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-msec, found to cause slight and extensive injury in a dolphin calf, were used as thresholds in the analysis contained in this document.

Level B (behavior response) 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 sound, is a threshold of 182 dB re 1µPa^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.

For multiple successive explosions (MSE) occurring underwater, 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. The non-TTS threshold is derived following the approach of the Churchill Final Environmental Impact Statement (FEIS) for the energy-based TTS threshold. The research on pure-tone exposures reported in Schlundt et al. (2000) and Finneran and Schlundt (2004) provided a threshold of 192 dB re 1µPa^2-s as the lowest TTS value. This value for pure-tone exposures is modified for explosives by (a) interpreting it as an energy metric, (b) reducing it by 10 dB to account for the time constant of the mammal ear, and (c) measuring the energy in 1/3 octave bands, the natural filter band of the ear. The resulting TTS threshold for explosives is 182 dB re 1µPa^2-s in any 1/3 octave band. As reported by Schlundt et al. (2000) and Finneran and Schlundt (2004), instances of altered behavior in the pure-tone research generally began five dB lower than those causing TTS. The non-TTS threshold is therefore derived by subtracting 5 dB from the 182 dB re 1µPa^2-s in any 1/3 octave band threshold, resulting in a 177 dB re 1µPa^2-s (EL) sub-TTS behavioral disturbance threshold for MSE. Table B-2 summarizes the threshold levels for analysis of explosives used in the GOA.

Table B-2 – Explosives Threshold Levels

Threshold Type	Threshold Level
Level A – 50% Eardrum rupture	205 dB re 1µPa^2-s
Temporary Threshold Shift (TTS) (peak 1/3 octave energy)	182 dB re 1µPa^2-s
Sub-TTS Threshold for Multiple Successive Explosions (peak 1/3 octave energy)	177 dB re 1µPa^2-s
Temporary Threshold Shift (TTS) (peak pressure)	23 psi
Level A – Slight lung injury (positive impulse)	13 psi-ms
Fatality – 1% Mortal lung injury (positive impulse)	31 psi-ms

The sound sources will be located in an area that is inhabited by species listed as threatened or endangered under the 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).

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 among the cognizant federal agencies under Section 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 Evaluation 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.

B.2 ACOUSTIC SOURCES

The acoustic sources employed in the TMAA 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 majority of acoustic energy results from narrowband sonars utilized for Anti-Submarine Warfare (ASW) activities and underwater explosions as broadband sources. 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.

B.2.1 Acoustic Sources

Operations in the TMAA involve four (4) types of narrowband sonars, as shown in Table B-3. Harassment estimates are calculated for each source according to the manner in which it operates. For example, the SQS-53 is a hull-mounted, surface ship sonar that operates for many hours at a time, so it is useful to calculate and report SQS-53 harassments per hour of operation. The AQS-22 is a helicopter-deployed sonar, which is lowered into the water, pings a number of times, and then moves to a new location. For the AQS-22, it is useful to calculate and report harassments per dip. The SSQ-62 sonobuoy is modeled at a single depth pinging for a fixed duration, so harassments are accordingly reported per sonobuoy deployed. The following table presents the deploying platform, frequency class, and the reporting metric for each acoustic source analyzed for use in the TMAA.

Table B-3 – Acoustic Sources Analyzed for use in the TMAA

Sonar	Description	Frequency Class	Harassments Reported
SQS-53	Surface ship sonar	Mid-frequency	Per hour
SSQ-62	Sonobuoy sonar	Mid-frequency	Per sonobuoy
AQS-22	Helicopter-dipping sonar	Mid-frequency	Per dip
SQS-56	Surface ship sonar	Mid-frequency	Per hour
MK-84 Range Pingers	Surface pingers	High-frequency	Per day
PUTR Transponders	Bottom pingers	Mid-frequency	Per day
MK-39 EMATT	Training target	Low frequency	Per hour
BQQ-10	Submarine sonar	Classified	Per hour
BQS-15	Submarine sonar	Classified	Per hour
SUS, MK-84	Expendable buoy	Mid-frequency	Per hour

The acoustic modeling that is necessary to support the harassment 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 $1\mu\text{Pa}^{2\text{-}}$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 θ is

$$\text{Power} = \max \{ \sin^2 [n(\theta_s - \theta)] / [n \sin (\theta_s - \theta)]^2, 0.01 \},$$

where θ_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 $\theta_w = 180^o/n$.

- 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, three 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.

These parameters are defined for each of the active sound sources in Tables B-4 and B-5.

Table B-4 – Source Description of Active Sources used in the TMAA

Sonar	Source Depth	Center Freq	Source Level	Emission Spacing	Vertical Directivity	Horizontal Directivity
SQS-53C	7 m	3.5 kHz	235 dB	154 m	Omni	240^o Forward-looking
SSQ-62	27 m	8 kHz	201 dB	450 m	Omni	Omni
AQS-22	27 m	4.1 kHz	217 dB	15 m	Omni	Omni
SQS-56	7 m	7.5 kHz	225 dB	129 m	Omni	90^o Forward-looking
MK-84 Range Pingers	7m, 100m	12.9 kHz	194 dB		90 Down	Omni
PUTR Transponders	1,800 m	8.8 kHz	186 dB	Variable	180 Upward	Omni
MK-39 EMATT	100 m	900 Hz	130 dB	Continuous	Omni	Omni
BQQ-10	100 m	Classified	Classified	Classified	Classified	Classified
BQS-15	50 m	Classified	Classified	Classified	Classified	Classified
SUS, MK-84	50 m	3.4 kHz	160 dB	Continuous	Omni	Omni

The following are the usage units for sonar sources in the TMAA (all modeled during the summer season):

Table B-5 – Sonar Usage Units

Sonar	2CSG	1CSG
SQS-53C	578 Hours	289 hours
SSQ-62	267 buoys	133 buoys
AQS-22	192 dips	96 dips
SQS-56	52 hours	26 hours
BQQ-10	48 hours	24 hours
BQS-15	24 hours	12 hours

B.2.2 Explosives

Explosives detonated underwater introduce loud, impulsive, broadband sounds into the marine environment. Three source parameters influence the effect of an explosive: the weight of the explosive material, the type of explosive material, and the detonation depth. The net explosive weight (or NEW) accounts for the first two parameters. The NEW of an explosive is the weight of TNT required to produce an equivalent explosive power.

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).

For the TMAA, explosive sources having detonations in the water include the following: SSQ-110 EER sonobuoys and MK-82, MK-83, MK-84, BDU-45 bombs, 5” rounds and 76 mm gunnery rounds, MK-48 torpedo, and Maverick missile. The SSQ-110 source can be detonated at several depths within the water column. For this analysis, a relatively shallow depth of 65 ft (20 m) is used to optimize the likelihood of the source being positioned in a surface duct. A source depth of two meters is used for bombs and missiles that do not strike their target. The MK-48 torpedo detonates immediately below the target’s hull and a nominal depth of 50 ft (14 m) is used as its source depth in this analysis. For the gunnery rounds, a source depth of one foot is used. The NEW modeled for these sources are as follows:

- SSQ-110 Sonobuoy – 5 pounds
- MK-82 bomb – 238 pounds
- MK-83 bomb – 238 pounds
- MK-83 bomb – 574 pounds
- MK-84 bomb – 945 pounds
- 5” rounds – 9.54 pounds
- 76 mm rounds – 1.6 pounds
- MK-48 torpedo – 851 pounds
- Air-to-Ground (AGM)-65 Maverick Missile – 78.5 pounds

The harassments expected to result from these sources are 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 movements as to ensure a different population of animals is considered for each detonation.

The cases in which simple addition of the harassment estimates may not be appropriate are addressed by the modeling of a “representative” sinking exercise (SINKEX). In a SINKEX, a decommissioned vessel 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. 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. With one exception, it is assumed that all missiles in a SINKEX will strike the target vessel. The Maverick missile and bombs used in SINKEX were modeled as missing the target vessel approximately 33 percent of the time. For all live rounds fired in a GUNEX and an estimated 32 percent of rounds fired in SINKEX may explode in the water.

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 B-6. Guided weapons are nearly 100% 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 B-6 – 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.

B.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 Anti-Submarine Warfare (ASW) exercises, 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 homogeneous and can be represented by a single set of environmental parameters) within the TMAA.

B.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 upon 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.

B.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, 1000, 2000, and 5000 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.

B.3.3 Description of Environmental Provinces

The TMAA is approximately 92,246 square kilometers of ocean located south of Prince William Sound and east of Kodiak Island. The TMAA encompasses Warning Area W-612 and extends from the continental shelf to the deep waters of the Gulf of Alaska. The acoustic sources described in subsection B.2 are deployed throughout the TMAA. This subsection describes the representative environmental provinces selected for the GOA. For all of these provinces, the average wind speed in the winter is 19 knots and in the summer 12 knots.

The GOA contains a total of 20 distinct environmental provinces. These represent various combinations of six bathymetry provinces, two Sound Velocity Profile (SVP) provinces, and four High-Frequency Bottom Loss (HFBL) classes.

The bathymetry provinces represent depths ranging from 100 meters to typical deep-water depths (slightly more than 5,000 meters). Nearly two-thirds of the TMAA is characterized as deep-water (depths of 2,000 meters or more). The second most prevalent water depth, covering nearly one-quarter of the TMAA, is representative of waters near the continental shelf break. The remaining water depths provide only small contributions (individually less than 5%) to the analysis. The distribution of the bathymetry provinces over the GOA is provided in Table B-7.

Table B-7 – Distribution of Bathymetry Provinces in GOA

Province Depth (m)	Frequency of Occurrence
100	4.85 %
200	22.29 %
500	4.22 %
1000	4.53 %
2000	12.67 %
5000	51.44 %

The distribution of the two sound speed provinces found in the TMAA is presented in Table B-8.

Table B-8 – Distribution of Sound Speed Provinces in GOA

SVP Province	Frequency of Occurrence
21	30.46 %
22	69.54 %

The variation in sound speed profiles associated with these two provinces is significant. This is illustrated in Figure B-1 and B-2 that display the upper 1,000 meters of the winter and summer profiles, respectively. In the winter, province 21 is a classic half-channel profile. The strong near-surface (within the upper 200 meters) gradient is the likely product of thorough mixing by strong winter winds and some fresh water sources. The winter profile for province 22 features a strong surface duct to a depth of 100 meters, also the result of thorough mixing by the winter winds. In contrast to province 21, however, the surface layer is modestly warmer. Nonetheless, both profiles are conducive to favorable sound propagation from a near-surface source.

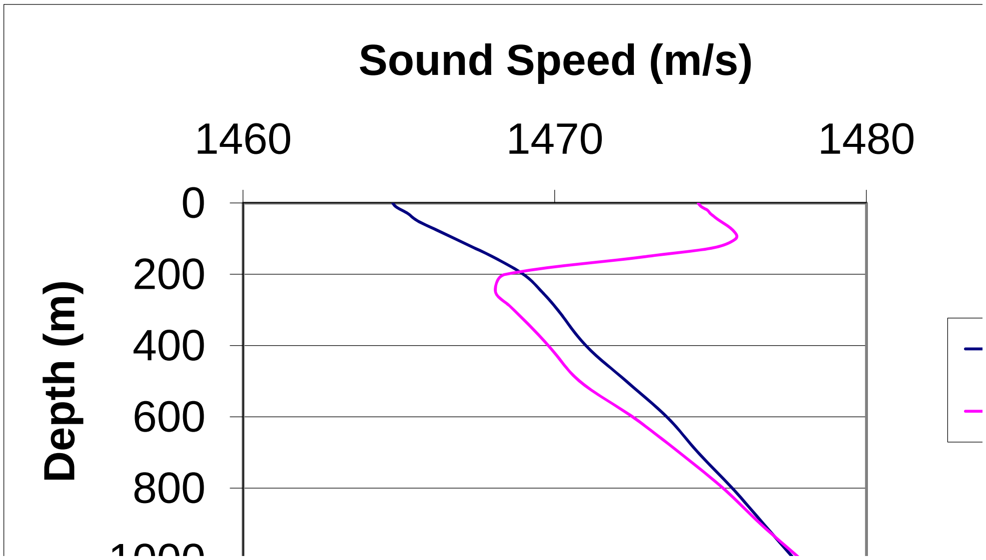

Figure B-1 – Winter SVPs in GOA

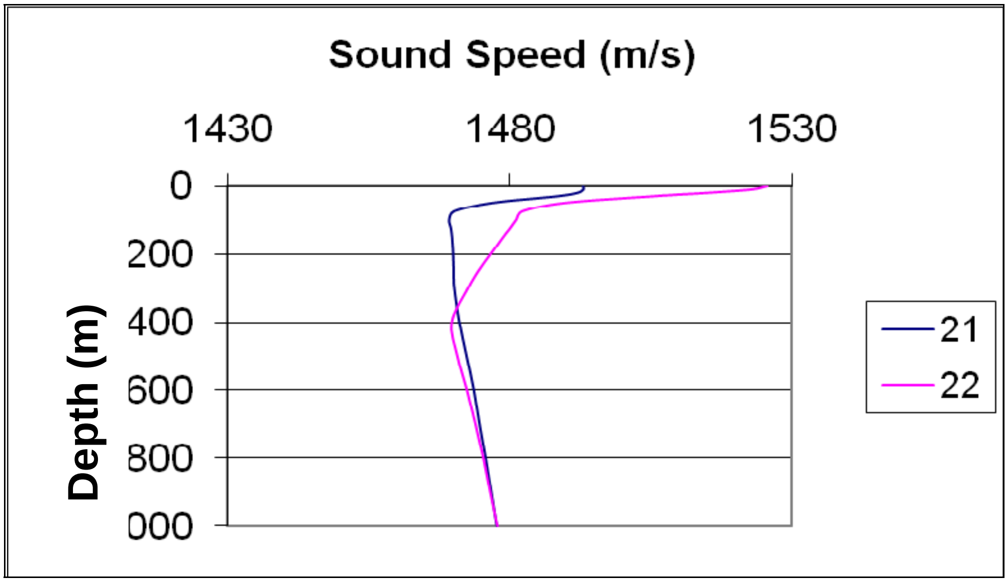

Figure B-2 – Summer SVPs in GOA.

The four HFBL classes represented in the GOA vary from low-loss bottoms (class 2, typically in shallow water) to high-loss bottoms (class 8). The four classes are fairly equally distributed as indicated in Table B-9 Distribution of High-Frequency Bottom Loss Classes in GOA. However, since two (classes 2 and 3) of the four classes are relatively low-loss, the bias in the environmental provinces will be towards low-loss bottoms.

Table B-9 – Distribution of High-Frequency Bottom Loss Classes in GOA

HFBL Class	Frequency of Occurrence
2	28.28 %
3	22.60 %
5	22.70 %
8	26.42 %

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 six 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 (in some cases almost exclusively) by a single HFBL class, so that the secondary differentiating environmental parameter is of no consequence.
- The 1000-meter bathymetry province has two environmental provinces (differing in SVP province only) that occur in small, but relatively equal portions. Although they collectively represent less than 5% of the TMAA, both are included in the analysis to ensure thoroughness. A third environmental province with a different HFBL class is not encountered enough to warrant consideration.
- The 2000-meter bathymetry province contains two environmental provinces that feature different SVP provinces. Both occur with sufficient frequency to warrant inclusion in the analysis.
- The 5000-meter bathymetry province consists of five environmental provinces. Four of these provinces are maintained for analysis; the fifth province is representative of less than one percent

of the TMAA and for that reason, is excluded from consideration.

The distribution of the resulting eleven environmental provinces used in the acoustic modeling is summarized in Table B-10 and depicted in Figure B-3.

Table B-10 – Distribution of Environmental Provinces in TMAA

Environmental Province	Water Depth	SVP Province	Frequency of Occurrence
1	100 m	21	4.85 %
2	200 m	21	22.29 %
3	500 m	21	4.22 %
4	1000 m	21	2.32 %
5	1000 m	22	2.21 %
6	2000 m	21	10.61 %
7	2000 m	22	2.06 %
8	5000 m	21	22.60 %
9	5000 m	21	21.20 %
10	5000 m	22	1.51 %
11	5000 m	21	6.13 %

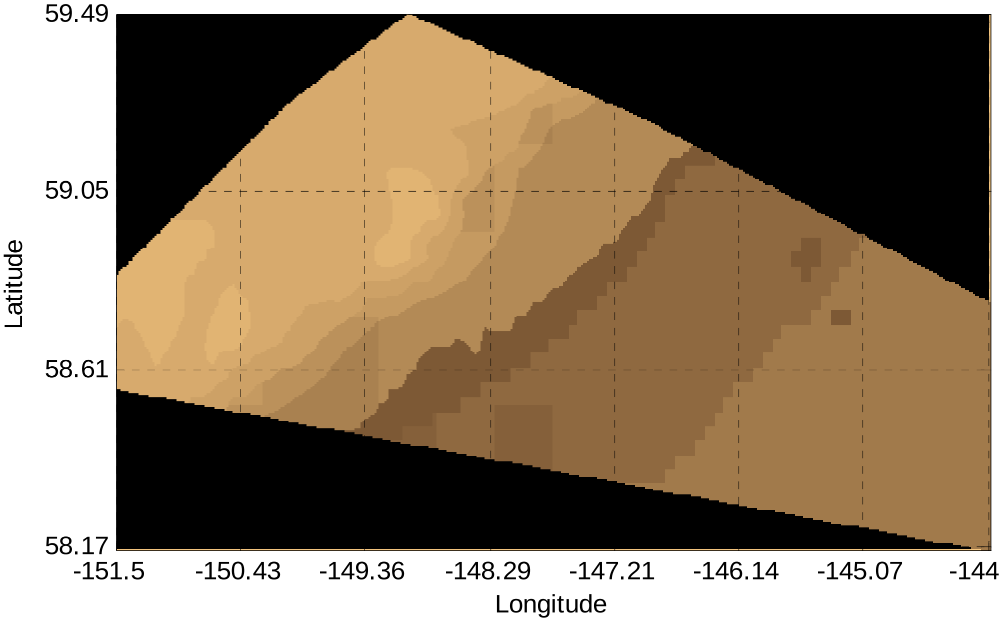

Figure B-3 – Distribution of Environmental Provinces in TMAA

On this plot, darker-colored regions correspond to higher environmental province numbers, and hence depict deeper regions of the TMAA.

SINKEX operations are restricted to areas outside of 50 nautical miles (nm) from land and in waters deeper than 1,000 fathoms (or 1,852 meters). These limitations result not only in a smaller set of environments for analysis but also different frequencies of occurrence as indicated in Table B-11.

Table B-11 – Distribution of Environmental Provinces in the TMAA SINKEX Area

Environmental Province	Water Depth	SVP Province	Sediment Thickness	Frequency of Occurrence
1	2000 m	21	0.2 secs	7.15 %
2	5000 m	21	0.94 secs	35.55 %
3	5000 m	21	0.29 secs	9.04 %
4	5000 m	21	0.81 secs	45.93 %
5	5000 m	22	0.92 secs	1.75 %
6	5000 m	22	0.67 secs	0.58 %

B.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 operations 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 harassments is estimated as the "product" (scalar or vector, depending upon 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 harassments is discussed in subsection B.6.

B.4.1 Computing Impact Volumes for Active Sound Sources

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.

B.4.1.1 Transmission Loss Calculations

Transmission loss (TL) data are pre-computed for each of two seasons in each of the environmental provinces described in the previous subsection using the Gaussian Ray Bundle (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 transmission loss suffered along the eigenray path.

The frequency and source depth TL inputs are specified in Table B-12.

Table B-12 – TL Frequency and Source Depth by Type

SONAR	FREQUENCY	SOURCE DEPTH
SQS-53	3.5 kHz	7 m
AQS-22	4.1 kHz	27 m
ASQ-62	8 kHz	27 m
SQS-56	7.5 kHz	7 m
MK-84 Range Pingers	12.9 kHz	7m, 100m
PUTR Transponders	8.8 kHz	1,800 m
MK-39 EMATT	900 Hz	100 m
BQQ-10	Classified	100 m
BQS-15	Classified	50 m
SUS, MK-84	3.4 kHz	50 m

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 B-13. Note that some of the low-power sources do not require TL data to large maximum ranges.

Table B-13 – TL Depth and Range Sampling Parameters by Sonar Type

SONAR	RANGE STEP	MAXIMUM RANGE	DEPTH SAMPLING
SQS-53	10 m	200 km	0 – 1 km in 5 m steps 1 km – Bottom in 10 m steps
AQS-22	10 m	10 km	0 – 1 km in 5 m steps 1 km – Bottom in 10 m steps
ASQ-62	5 m	5 km	0 – 1 km in 5 m steps 1 km – Bottom in 10 m steps
SQS-56	10 m	50 km	0 – 1 km in 5 m steps 1 km – Bottom in 10 m steps
MK-84 Range Pingers	5 m	15 km	0 – 1 km in 5 m steps 1 km – Bottom in 10 m steps
PUTR Transponders	5 m	15 km	0 – 1 km in 5 m steps 1 km – Bottom in 10 m steps
MK-39 EMATT	5 m	1 km	1 m steps
BQQ-10	Classified	Classified	0 – 1 km in 5 m steps 1 km – Bottom in 10 m steps
BQS-15	Classified	Classified	0 – 1 km in 5 m steps 1 km – Bottom in 10 m steps
SUS, MK-84	5 m	1 km	1 m steps

In a few cases, most notably the SQS-53 for levels 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 transmission loss 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.

B.4.1.2 Energy Summation

The summation of energy flux density 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 energy flux density 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 transmission loss is greater than the threshold. Next, the source is moved along a straight-line track and energy flux density is accumulated at a point that has a CPA range of R_{max} at the mid-point of the source track. That total energy flux density 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 ten 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 energy flux density 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 on 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 B-4 below.

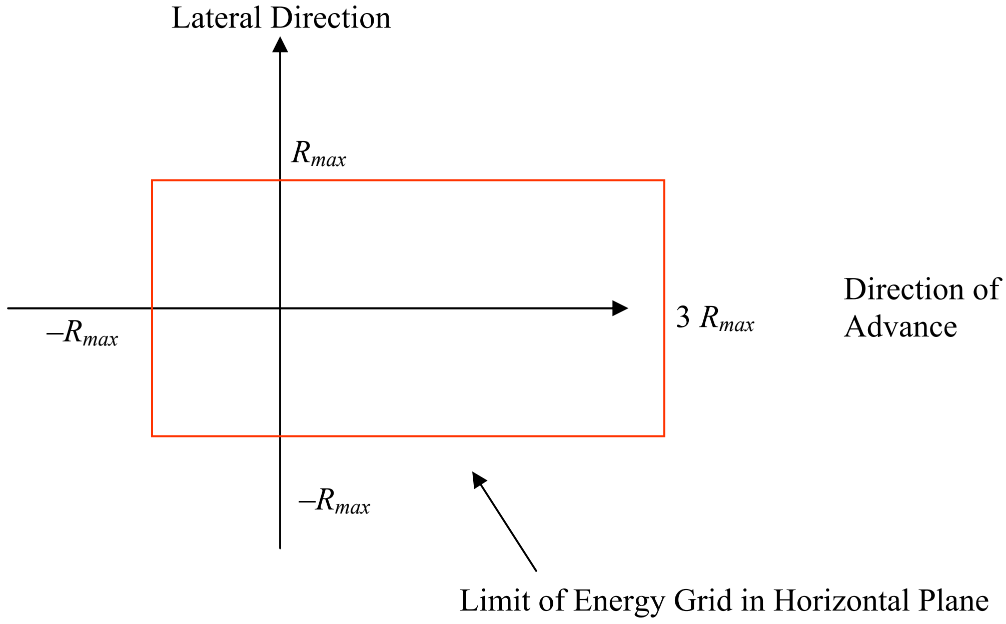

Figure B-4 – Horizontal Plane of Volumetric Grid for Omni-Directional Source

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 B-5.

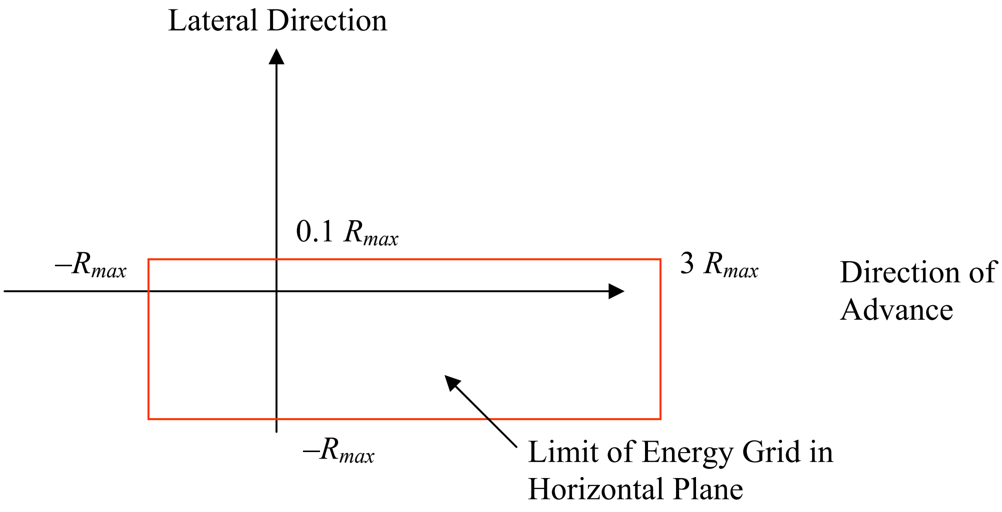

Figure B-5 – Horizontal Plane of Volumetric Grid for Starboard Beam Source

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 one 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 ten meters to ensure that significant TL variability over depth is captured.

B.4.1.3 Impact Volume per Hour of Source Operation

The impact volume for a source 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 B-6 using the SQS-53 as an example.

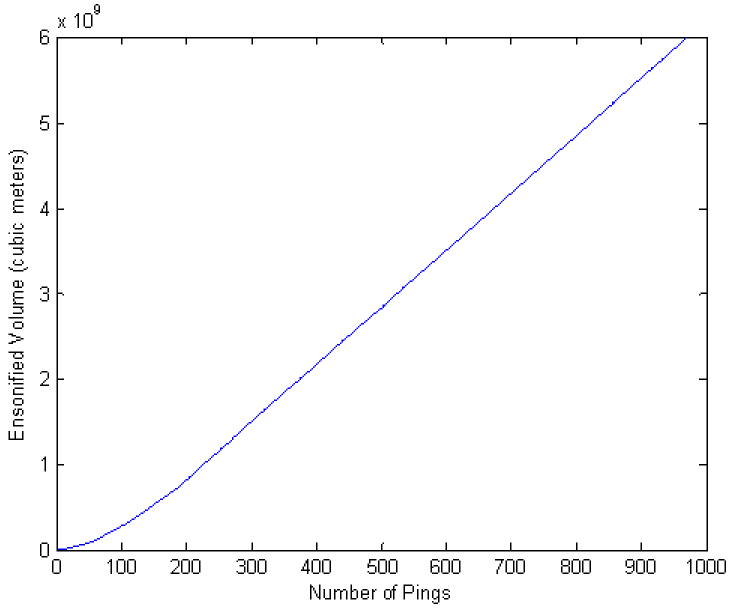

Figure B-6 – SQS-53 Impact Volume by Ping

The slope of the asymptotic limit of the impact volume 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, v_n, which contains the hourly impact volumes by depth for province n. Figure B-7 provides an example of an hourly impact volume vector for a particular environment.

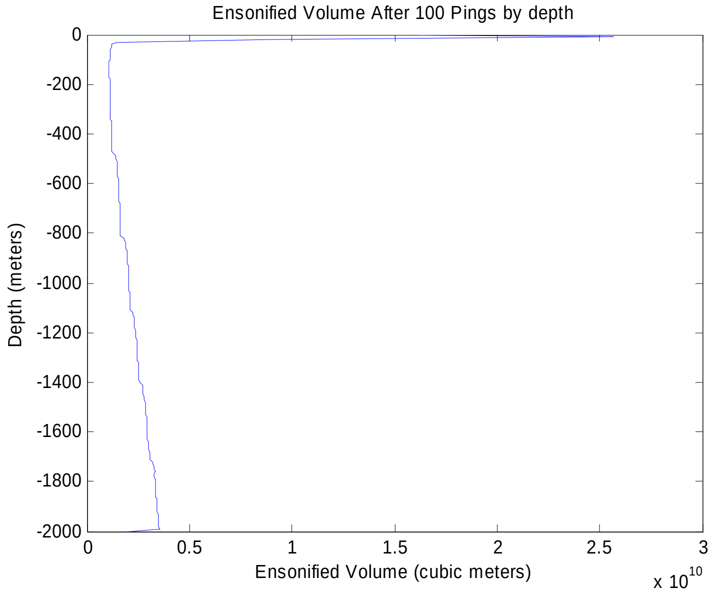

Figure B-7 – Example of an Impact Volume Vector

B.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 B.4.2.3.

B.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:

$$\sin^2\left(\frac{4\pi f z_s z_a}{c^2 t}\right)$$

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.

B.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 B.2.2.

The effective energy source level, which is treated as a de facto input for the other sources, is instead modeled directly for SSQ-110 explosive sonobuoys 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:

$$\mathrm{ESL} = 10\log_{10}(0.26f) + 10\log_{10}\left(2\,p_{max}^{2} / [1/\theta^{2} + 4\pi f^{2}]\right) + 197\ \mathrm{dB}$$

where the peak pressure for the shock wave at one meter is defined as

$$p_{max} = 21600\,(w^{1/3} / 3.28)^{1.13}\ \mathrm{psi} \qquad \text{(A-1)}$$

and the time constant is defined as:

$$\theta = [(0.058)\,(w^{1/3})\,(3.28 / w^{1/3})^{0.22}] / 1000\ \mathrm{msec} \qquad \text{(A-2)}$$

In contrast to munitions that are modeled as omni-directional sources, the SSQ-110 is a directed source consisting 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 r 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 / λ where L is the array length and λ 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 B-8 and Figure B-9. 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 B-8 shows the rise of a single main lobe as range increases.

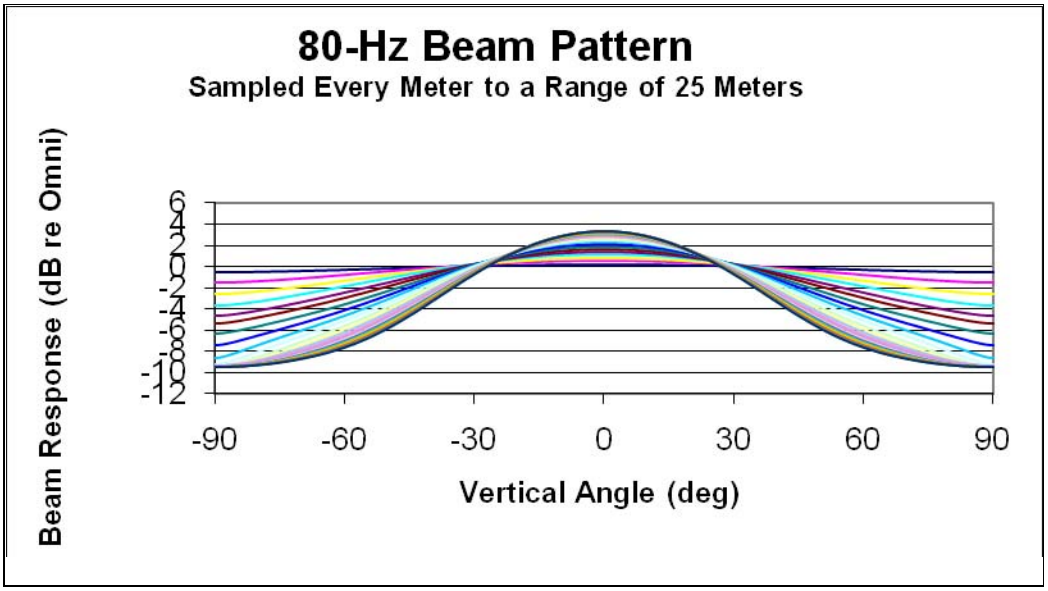

Figure B-8 – 80-Hz Beam Patterns across Near Field of EER Source

On the other hand, the 1250-Hz family of beam patterns depicted in Figure B-9 demonstrates the typical high-frequency bifurcated beam.

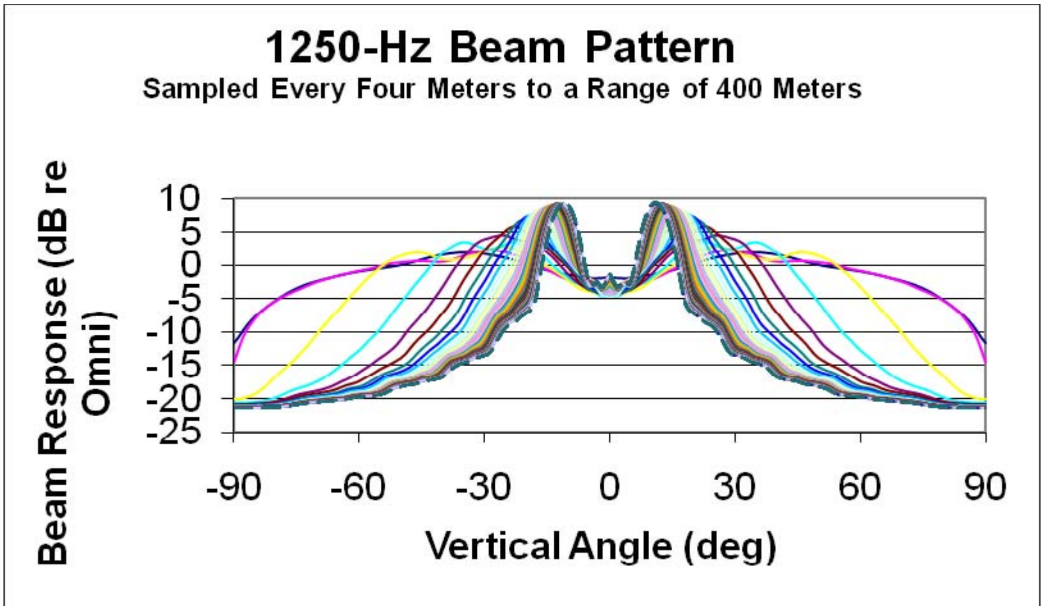

Figure B-9 – 1250-Hz Beam Patterns across Near Field of SSQ-110 Source

B.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.

B.4.2.3.1 *Peak One-Third Octave Energy Metric*

The computation of impact volumes for the energy metric closely follows the approach taken to model the energy metric for the active sonars. The only significant difference is that energy flux density is sampled at several frequencies in one-third-octave bands and only the peak one-third-octave level is accumulated over time.

B.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 A-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.

B.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

$$\int_0^{T_{min}} p(t)\,\mathrm{d}t$$

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 one 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% 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% 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.

B.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.

B.4.3 Impact Volume by Region

The TMAA is described by eleven (11) environmental provinces. The hourly impact volume vector for operations involving any particular source is a linear combination of the eleven impact volume vectors with the weighting determined by the distribution of those eleven environmental provinces within the range. Unique hourly impact volume vectors for summer are calculated for each type of source and each metric/threshold combination.

B.5 RISK FUNCTION: THEORETICAL AND PRACTICAL IMPLEMENTATION

This section discusses the recent addition of a risk function response "threshold" to acoustic effects analysis procedure. This approach includes two parts; a metric, and a function to map exposure level under the new metric to probability of harassment for acoustic sources. What these two parts mean, how they affect exposure calculations, and how they are implemented are the objects of discussion.

B.5.1 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 B-10 gives the time series of the first "hallelujah" in Handel's Hallelujah Chorus.

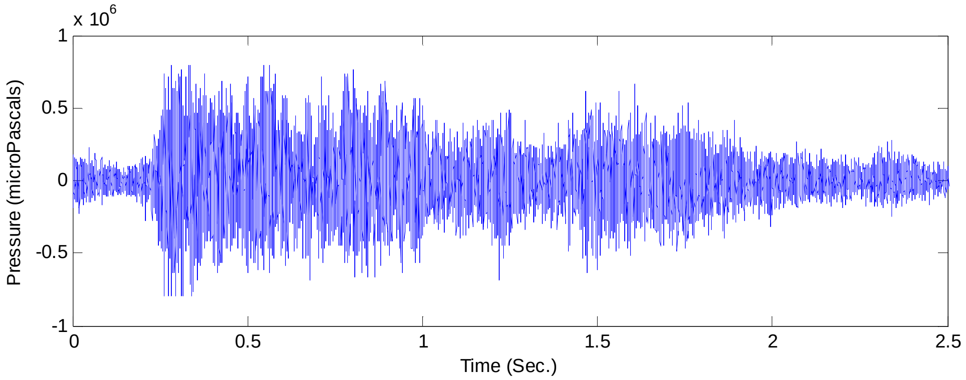

Figure B-10 – Time Series

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 space. 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 B-10 $p(t)$ 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 B-10, 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 B-11 is $p^2(t;0,10,-4)$.

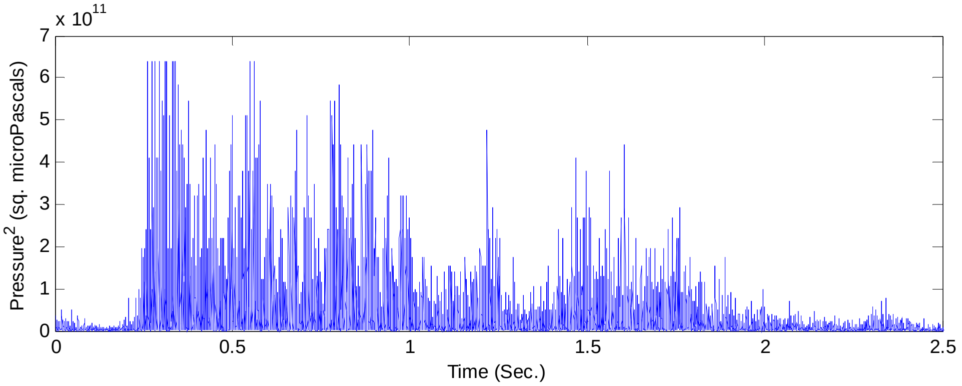

Figure B-11 – Time Series Squared

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 B-10, to a single value for each point (x,y,z) in 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 Sound Pressure Levels (SPLs). SPL is actually the ratio of acoustic power and density (power/unit area = $\frac{p^2}{Z}$ where $Z = \rho c$ is the acoustic impedance). This ratio is presented on a logarithmic scale relative to a reference pressure level, and is defined as:

$$SPL = 10\log_{10}\left(\frac{p^2}{p_{ref}^2}\right) = 20\log_{10}\left(abs\left(\frac{p}{p_{ref}}\right)\right)$$

(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 $1\mu Pa^2$-s) for $0<t<2.5$

The $SPL_{\max}$ for this snippet of the Hallelujah Chorus is $10\log_{10}(6.4\times10^{11}\,\mu Pa^2/1\mu Pa^2) = 118\,dB$ re $1\mu Pa^2$-s which occurs at 0.2606 seconds, as shown in Figure B-12.

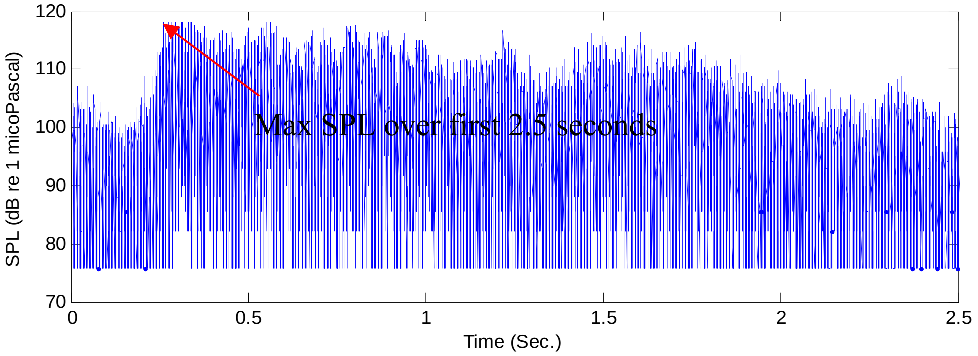

Figure B-12 – Max SPL of Time Series Squared

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 EFD, which accounts for this duration. A simple integration of $p^2(t;x,y,z)$ over t is common and is proportional to the EFD 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 energy level (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 we have

$$\int_0^{2T} p^2(t)dt = 2\int_0^T p^2(t)dt = \int_0^T 2p^2(t)dt,$$

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 $10\log_{10}(2)=3.01$ 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

$m_a(x,y,z,T)$ = value of metric "a" at point (x,y,z) after time T

So,

$$m_{energy}(x,y,z;T) = \int_0^T p(t)^2\,dt$$

$$m_{\max\ SPL}(x,y,z;T) = \max 10\log_{10}\left(p^2(t)\right) over \ [0,T]$$

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

$$D(m_a(x,y,z)) = P(effect\ at\ m_a(x,y,z))$$

The domain of D is the range of $m_a(x,y,z)$, and the range of D is [0,1].

An example of threshold functions is the heavyside (or unit step) function, currently used to determine permanent and temporary threshold shift (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 B-13.

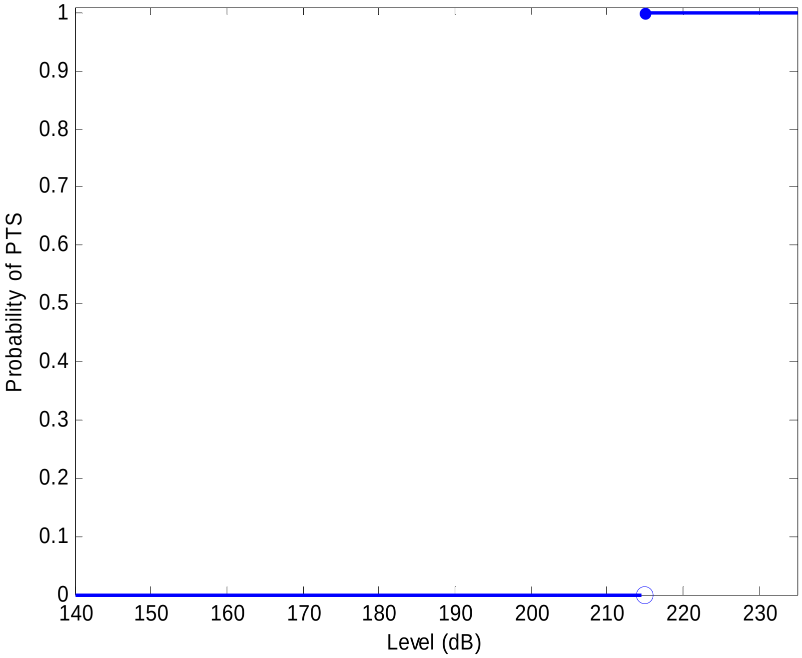

Figure B-13 – PTS Heavyside Threshold Function

Symbolically, 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% effect, and a steepness parameter. Mathematically, these Feller, "risk" functions, *D*, are defined as

$$D(m_{\max SPL}) = \begin{cases} \dfrac{1}{1+\left(\dfrac{K}{m_{\max SPL}-B}\right)^{A}} \; for \; m_{\max SPL} \geq B \\ 0 \qquad\qquad\qquad for \; m_{\max SPL} < B \end{cases} \qquad 1$$

where *B* = cutoff (or basement), *K* = the difference in level (dB) between the basement and the median (50% 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 % to 100 %) at 120 dB. All other species use the continuous Feller risk-function for evaluating expected harassment.

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

$$\int_V \rho(V) D\big(m_a(V)\big) dV = \int_{-\infty}^{\infty}\int_{-\infty}^{\infty}\int_{-\infty}^{\infty} \rho(x,y,z) D(m_{\max SPL}(x,y,z)) \, dx \, dy \, dz$$

In this analysis, the densities are constant over the *xy*-plane, and the *z* dimension is always negative, so this reduces to

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1 The equation can also be represented as shown in Section 3.8.6.3 of this EIS/OEIS

$$\int_{-\infty}^{0} \rho(z) \int_{-\infty}^{\infty}\int_{-\infty}^{\infty} D(m_{\max SPL}(x,y,z))\, dx\, dy\, dz$$

Numeric Implementation

Numeric integration of $\int_{-\infty}^{0} \rho(z) \int_{-\infty}^{\infty}\int_{-\infty}^{\infty} D(m_{\max SPL}(x,y,z))\, dx\, dy\, dz$ can be involved because, although the bounds are infinite, D is non-negative out to 120 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 *xy*-plane portion of the integral:

$$\text{Define } f(z) = \int_{-\infty}^{\infty}\int_{-\infty}^{\infty} D(m_{\max SPL}(x,y,z))\, dx\, dy\,.$$

Calculation of this integral is the most involved and time consuming part of the calculation. Once it is complete,

$$\int_{-\infty}^{0} \rho(z) \int_{-\infty}^{\infty}\int_{-\infty}^{\infty} D(m_{\max SPL}(x,y,z))\, dx\, dy\, dz = \int_{-\infty}^{0} \rho(z) f(z) dz\,,$$

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. Smaller sized intervals yield closer approximations with longer calculation time, 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 1000 meters in depth and 10 meter steps to 2000 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,

$$\begin{aligned}
&z \in Z = \{0,5,...1000,1010,...,2000\} \\
&x \in X = \{0,\pm 5,...,\pm 5k\} \\
&y \in Y = \left\{0,\pm 5 * (1.005)^0, \pm 5 * \left[(1.005)^0 + (1.005)^1\right],..., \pm 5 * \left[\sum_{i=0}^{j} (1.005)^i\right]\right\}
\end{aligned}$$

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, this equation 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 (120 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 × 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 a 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, and 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 aforementioned Feller function to determine the probability that an animal is affected by a given sound pressure level. The acoustic quantity of interest is the maximum sound pressure level (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 transmission loss (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 sound pressure level. This gives the impact volume for that depth, which 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 sound 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 *xy*-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 B-14 shows an example volume histogram for a low-power source. 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 to 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 evaluated at that level. Total expected impact volume for a given depth is the sum of these “expected” volumes.

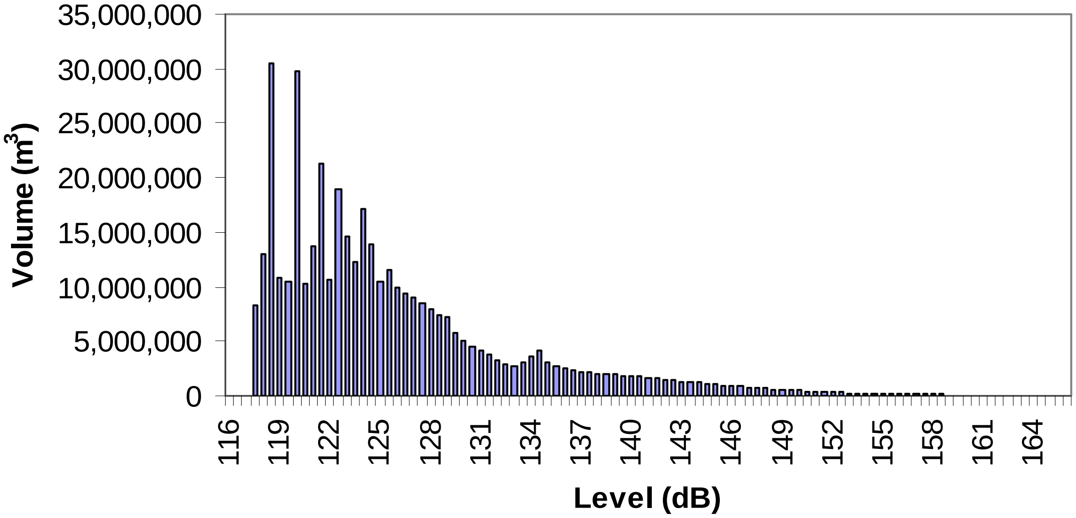


Figure B-14 – Example of a Volume Histogram

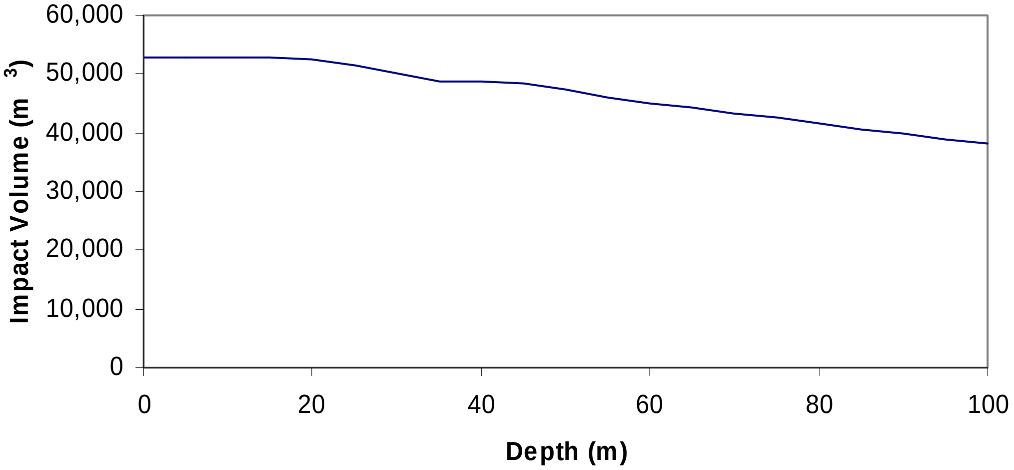


Figure B-15 – Example of the Dependence of Impact Volume on Depth

The volumetric grid covers the waters in and around the area of a source's 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 where 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 100th 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 $-R_{max}$ to $+R_{max}$, where R_{max} is the maximum range used in the TL calculations. The *z* direction uses a uniform spacing of 5 meters down to 1000 meters and 10 meters from 1000 to 2000 meters. This is the same depth mesh used for the effective energy metric as described above. The depth mesh does not extend below 2000 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 B-16 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 5 m 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%. A grid size of 5 meters for the *x*-axis is used in the calculations.

Figure B-17 shows the relative change of impact volume for one ping as a function of the grid size used for the x-axis and the *y*-axis grids, respectively. The *x*-axis grid size is fixed at 5 meters and the *y*-axis growth factor is 0. The impact volume for a 5 meters 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%. A grid size of 5 meters is used for the *y*-axis in our calculations. Figure B-18 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%. A growth factor of 0.005 is used in the calculations.

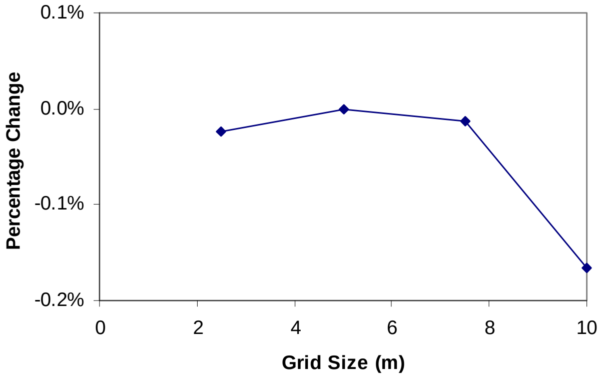


Figure B-16 – Change of Impact Volume as a Function of x-axis Grid Size.

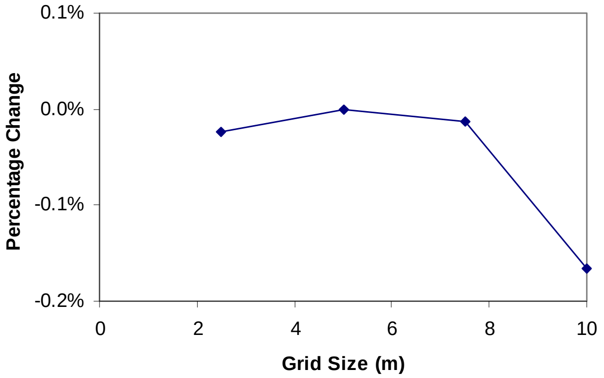


Figure B-17 – Change of Impact Volume as a Function of y-axis Grid Size

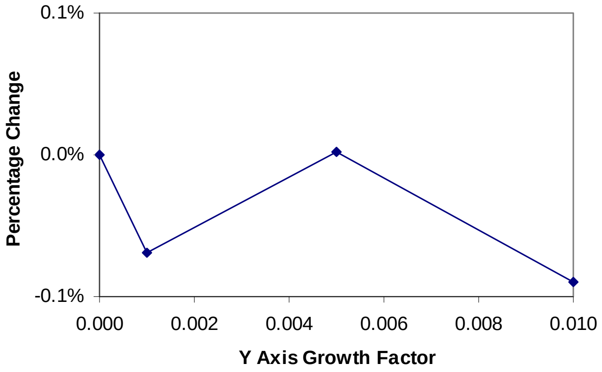


Figure B-18 – Change of Impact Volume as a Function of y-axis Growth Factor

Another factor influencing the accuracy of the calculation of impact volumes is the size of the bins used for sound pressure level. The sound pressure level bins extend from 100 dB (far lower than required) up to 300 dB (much higher than that expected for any sonar system).

Figure B-19 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, and the initial *y*-axis grid size is 5 meters with a *y*-axis growth factor of 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%. A bin width of 0.5 is used in our calculations.

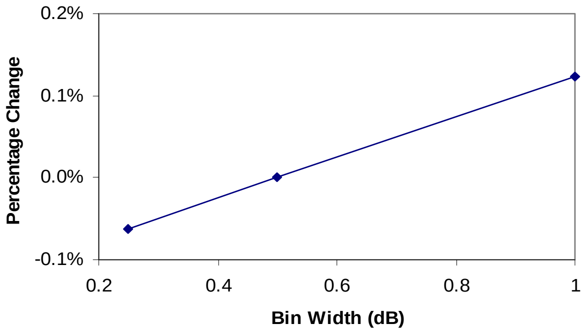


Figure B-19 – Change of Impact Volume as a Function of Bin Width

Two other issues for discussion are the maximum range (R_{max}) 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 R_{max} needs some discussion since it is not clear that the same value can be used for both metrics. R_{max} was set so that the TL at R_{max} is more than needed to reach the energy accumulation threshold of 173 dB for 1000 pings. Since energy is accumulated, the same TL can be used for one ping with the source level increased by 30 dB ($10 \log_{10}(1000)$). 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 1000 pings will also support calculation of impact volumes for the risk function metric.

The process of obtaining the maximum sound pressure level 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 source 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 sound pressure level at a grid point, the sound pressure level of the source is reduced by that TL. For the first ping, the volumetric grid is populated by the calculated sound pressure level 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 sound pressure level for each grid point is again calculated for the new source location. Since the risk-function metric uses the maximum of the sound pressure levels at each grid point, the newly calculated sound pressure level at each grid point is compared to the sound pressure level 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 sound pressure level.

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 B-14. 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 B-15, 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 B-20 shows the dependence of impact volume on the number of pings. 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.

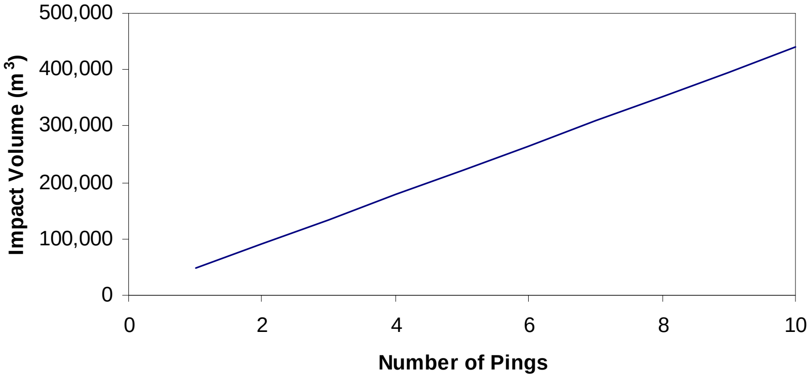


Figure B-20 – Dependence of Impact Volume on the Number of Pings

Figure B-21 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.

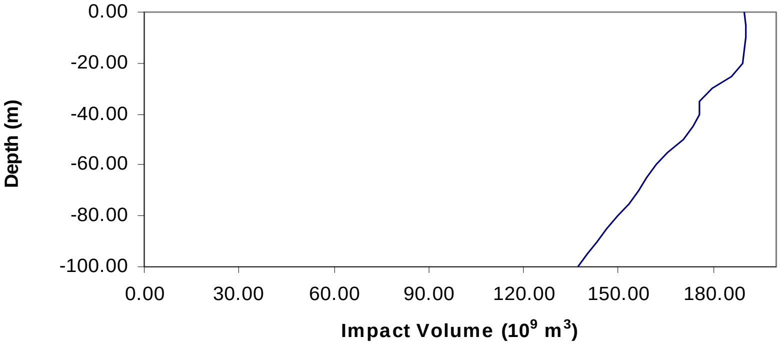


Figure B-21 – Example of an Hourly Impact Volume Vector

Modeling Quiet and Continuous Sources

The TMAA has modeled sources whose energy contributions do not exceed EFDL thresholds, but have source levels above 120 dB, and move in a continuous fashion. The previous discussion of software detail would present under-sampling artifacts when applied to quiet sources, so an alternative approach is implemented.

Consider transmission loss with cylindrical symmetry surrounding an omni-directional source (Figure B-22):

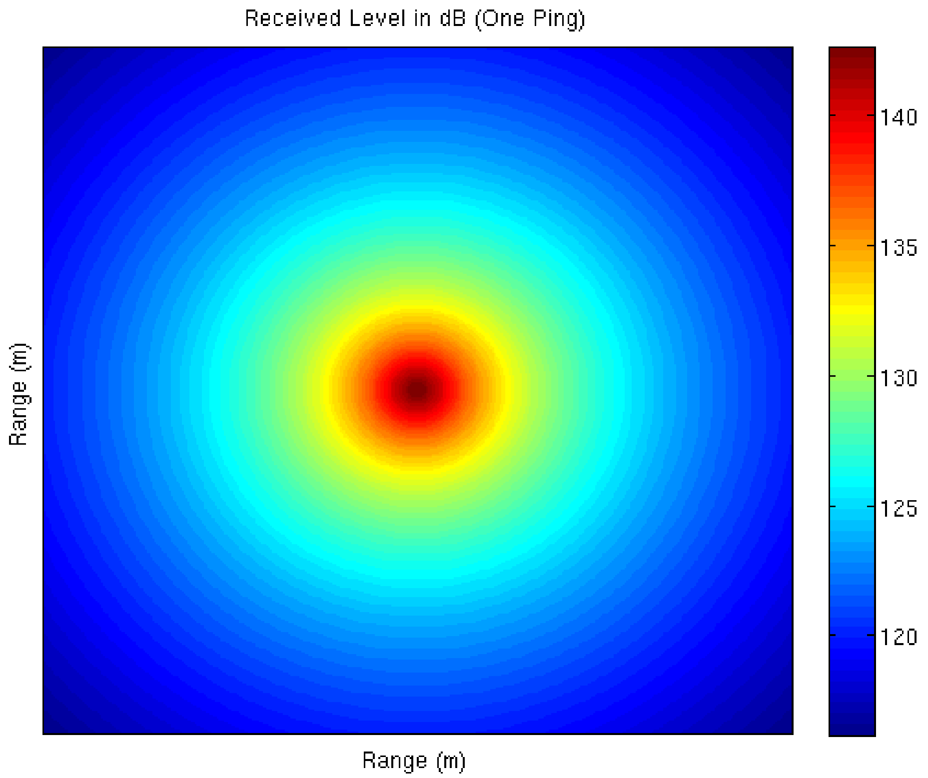


Figure B-22 – Single Ping Maximum SPL Field

When the factors of continuous pinging behavior, monotonic transmission loss in the short range, and maximum SPL as the input metric for the risk function, computing the maximum SPL field is a matter of extending the field as such (Figure B-23):

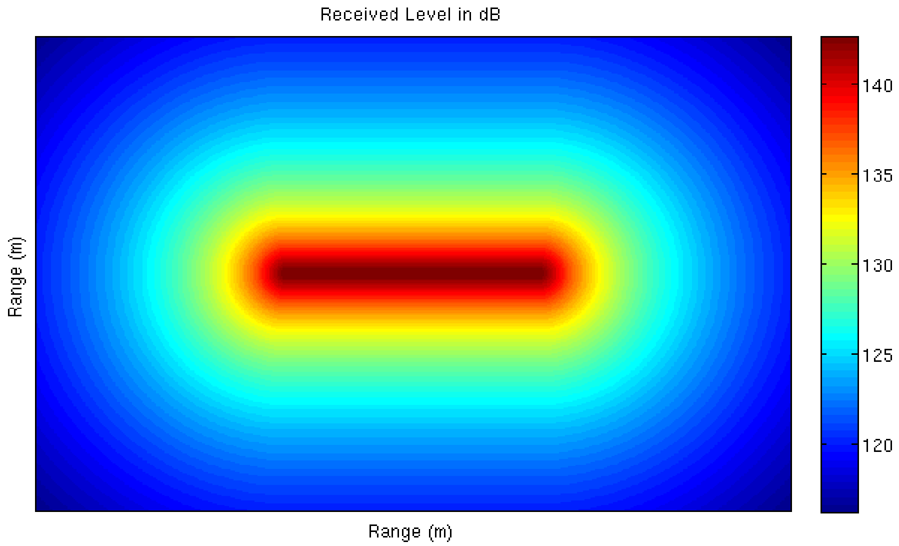


Figure B-23 – Quiet Continuous Sound Source

In the direction orthogonal to source motion, maximum SPL is achieved at CPA. This algorithm takes a 0.5-meter resolution frequency-dependent TL curve and proceeds as follows.

In a given depth interval:

- Find the received level in one meter increments about a source. In the first one meter step, calculate the area of circle ensonified at the matching received level.
- Calculate areas of subsequent n^{th} circles in 1 meter steps.
- Compute the area on a rectangular strip for a one-meter extent in parallel to annulus radius of equivalent received level. Scale by the probability of harassment based on received level at this n^{th} range. Note that received level at the outer-radius of the modified annulus was used to calculate the probability with the risk function.
- Convert annulus result to volume based on the depth increment.
- Sum all scaled volumes of interior cylinder and subsequent annuli to impact range at 120 dB to find a cumulative volume for this depth interval which inherits the probabilistic calculation.

This algorithm takes place over the entire water column to capture dynamics of ensonification over all depths, and hence produces an impact volume vector.

B.6 HARASSMENTS

This section defines the animal densities and their depth distributions for the TMAA. This is followed by a series of tables providing MMPA harassment estimates per unit of operation for each source type (active sound sources and explosives).

B.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 B.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.

B.6.2 Harassment 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 0.0003 whales per square kilometer. From the depth distribution report, "depth distribution for sperm whales based on information in the Amano paper is: 31% in 0-10 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." So the sperm whale density at 0-10 m is 0.0003*0.31/0.01 = 0.0093 per cubic km, at 10-200 m is 0.0003*0.08/0.19 = .00012632 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 0-10 meters, 10-50 meters, and 50-200 meters. Then for the depth-distributed densities discussed in the preceding paragraph,

- 0.0093 whales per cubic km is used for 0-10 meters,
- 0.00012632 whales per cubic km is used for the 10-50 meters, and
- 0.00012632 whales per cubic km is used for the 50-200 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).

B.6.3 Additional Modeling Considerations in a General Modeling Scenario

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 TMAA, 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 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 B-14 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:

Table B-14 – Unknowns and Assumptions

Unknowns	Relevance	Assumption
Path of source (esp. with respect to animals)	Ambiguity of multiple exposures, Local population: upper bound of harassments	Most conservative case: sources can be anywhere within range
Source locations	Ambiguity of multiple exposures, land shadow	Equal distribution of action in each range
Direction of sonar transmission	Land shadow	Equal probability of pointing any direction

The following sections discuss two 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, and land shadow.

B.6.4 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 propagation. A sound 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 affects.

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 range. Thus, if the farthest range to a possible effect from the source is *X* km, no animals farther than *X* km outside of the TMAA 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 TMAA, 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 TMAA 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 exercise means that multiple exposures cannot be calculated for any individual animal. It must be dealt with generally at the population level.

B.6.4.1 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 in the exercise. 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% 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% chance of harassment, its contribution increases to 0.7. If two animals receive a level that indicates 50% 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 exercise 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 produces 100 expected harassments, then action A in an area with 1 animal per square kilometer produces 50 expected harassments. The modeling produces the number of expected harassments per ping starting with 100% 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% of which are initially unharassed. After the first ping, 99 animals are unharassed, so the number of animals harassed during the second ping are

$$1\left(\frac{99}{100}\right) = 1(.99) = 0.99 \text{ animals}$$

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% unharassed population. H is calculated by determining the expected harassments 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 B-24).

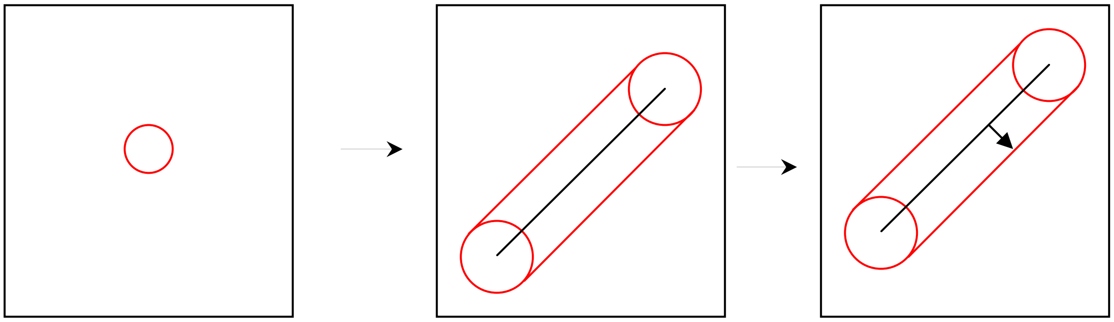


Figure B-24 – Process of Calculating H

$$H = \frac{\iiint \rho(z)D(L(x,y,z))dxdydz}{N_{pings}}$$

The total un-harassed population is then calculated by iteration. Each ping affects the un-harassed population left after all previous pings:

Define P_n = unharassed population after n^{th} ping

$$P_0 = \text{local population}$$

$$P_1 = P_0 - H$$

$$P_2 = P_1 - H\left(\frac{P_1}{P_0}\right)$$

$$\ldots$$

$$P_n = P_{n-1} - H\left(\frac{P_{n-1}}{P_0}\right)$$

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 un-harassed population, the local population size, and the number of operation hours.

B.6.4.2 Local Population: Upper Bound on Harassments

As discussed above, Navy planners have confined periods of sonar use to operation 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 operating 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 operation 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 harassments from an exercise.

NMFS has defined a twenty-four hour "refresh rate," or amount of time in which an individual animal can be harassed no more than once. The Navy has determined that, in a twenty-four hour period, all training events in the TMAA involve sources that transmit for no longer than sixteen (16) hours.

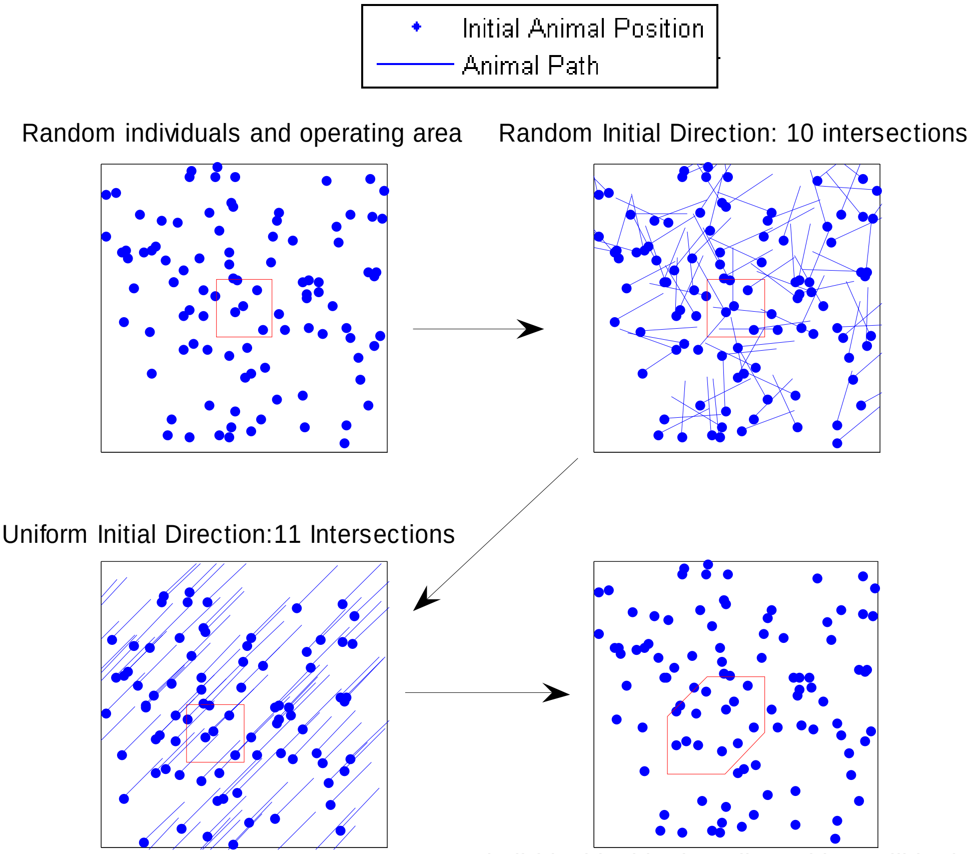
The most conservative assumption for a single ping is that it harasses the entire population within the range (a gross over-estimate). However, the total harassable population for multiple pings will be even greater since animal motion over the period can bring animals into range that otherwise would be out of the harassable population.

B.6.4.3 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 TMAA 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 expansions use this estimate as an absolute upper bound on animal-motion expansion.

Figure B-25 illustrates the overestimation, which occurs during the second arrow:



An individual inside the adjusted box will be in the original box sometime during the period of interest.

Figure B-25 – 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 B-25 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 ship 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 B-26. Using this smaller population would lead to a greater dilution of the unharassed population per ping and would greatly reduce the estimated harassments.

B.6.4.4 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 GOA, this would include all area within approximately 105 km from the edge of the adjusted box. (See Table B-15). 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 source 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% probability of harassment, and those outside the area a varying probability, based on the risk function.

$$\int_{0}^{L^{-1}(120\,dB)} D(L(r))dr\,,$$

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

$$\frac{[\pi-\theta]\displaystyle\int_{0}^{L^{-1}(120\,dB)} D(L(r))rdr}{2\pi}$$

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 TMAA, 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.

The following plots (Figure B-26) illustrate 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 operations.

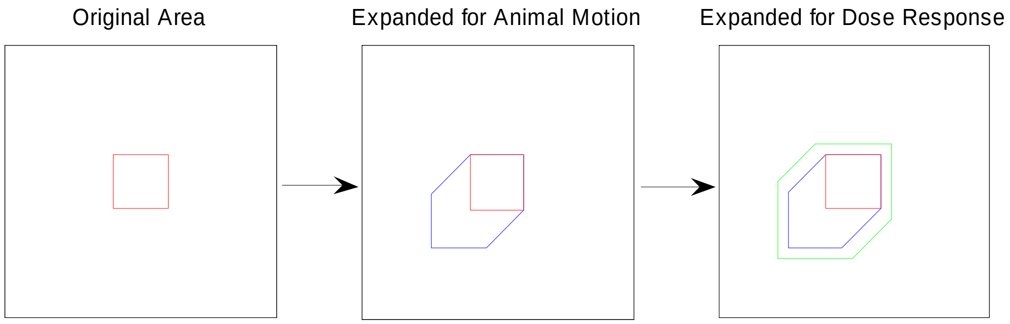


Figure B-26 – Process of Expanding Area to Create Upper Bound of Harassments

Example Case

Consider a sample case from the TMAA. For the most powerful source, the SQS-53, the expected winter rate of exposures under the risk function considered behaviorial MMPA Level B harassment for minke whales is approximately 0.068985832 harassments per ping. The exercise will transmit sonar pings for 16 hours in a 24 hour period as consistent with planned use, with 120 pings per minute, a total of 120 * 16 = 1,920 pings in a 24 hour period.

The TMAA has an area of approximately 92,246 square kilometers and a diagonal of 486.5 km. Adjusting this with straight-line (upper bound) animal motion of 5.5 kilometers per hour for 16 hours, animal motion adds 486.5 * 5.5 * 16 = 42,812 square kilometers to the area. Using the risk function to calculate the expected range outside the OA approximately adds another 5,068 square kilometers, bringing the total upper-bound of the affected area to 140,126 square km.

For example, minke whales have an average winter density of 0.0006 animals per square kilometer, so the upper bound number of minke whales that can be affected by SQS-53 activity in the GOA during a 24 hour period is 140,126 * 0.0006 = 84.0756 whales.

In the first ping, 0.068985832 minke whales will be harassed. With the second ping,

$0.068985832\left(\frac{84.0756 - 0.068985832}{84.0756}\right) = 0.068929228$ minke whales will be harassed. Using the formula derived above, after 16 hours of continuous operation, the remaining **unharassed** population is

$$P_{1920} = P_0\left(1-\left(\frac{h}{P_0}\right)\right)^{1920} = 84.0756\left(1-\left(\frac{0.068985832}{84.0756}\right)\right)^{1920} \approx 17.3861$$

So the **harassed** population will be 84.0756 – 17.3861 = 66.6895 animals.

Contrast this with linear accumulation of harassments without consideration of the local population and the dilution of the unharassed population:

Harassments = 0.068985832 * 1920 = 132.45 whales,

which is 57% greater than the estimated local population of 84.0756 minke whales. Because linear accumulation assumes an infinite local population, it always overestimates the number of harassments, sometimes to the point of producing impossible results.

B.6.5 Land Shadow

The risk function considers the possibility of harassment possible if an animal receives 120 dB sound pressure level, or above. In the open ocean of the MAA, this can occur as far away as 105 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 GOA, 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 each of the coastal points that are within 105 km of the grid, the azimuth and distance are computed. In the computation, only the minimum range at each azimuth is computed.

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.

B.6.5.1 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. The levels vary according to acoustic propagation conditions, so the analysis breaks down according to two seasons. Table B-15 give a mathematical extrapolation of the distances and levels at which harassments occur, with average seasonal propagation in the GOA using the SQS-53 as an example and as displayed in Figures B-27 and B-28.

Table B-15 – Behavioral Harassments at each Received Level Band from SQS-53 During Summer Months

Received Level (dB SPL)	Distance at which Levels Occur in GOA	Percent of Behavioral Harassments Occurring at Given Levels
Below 138	42 km – 105 km	~ 0 %
138<Level<144	28 km – 42 km	< 1 %
144<Level<150	17 km – 28 km	~1 %
150<Level<156	9 km – 17 km	7 %
156<Level<162	5 km – 9 km	18 %
162<Level<168	2.5 km – 5 km	26 %
168<Level<174	1.2 km – 2.5 km	22 %
174<Level<180	0.5 km – 1.2 km	14 %
180<Level<186	335 m – 0.5 km	6 %
186<Level<TTS	178 m – 335 m	5 %

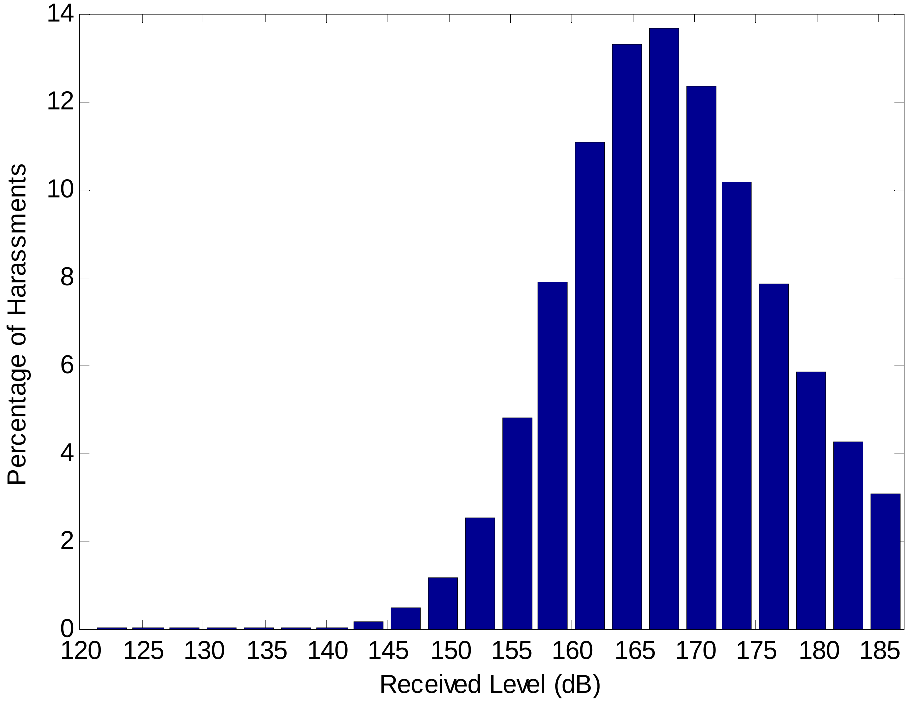


Figure B-27 – The Approximate Percentage of Behavioral Harassments for Every 3 Degree Band of Received Level from the SQS-53 During Summer Months

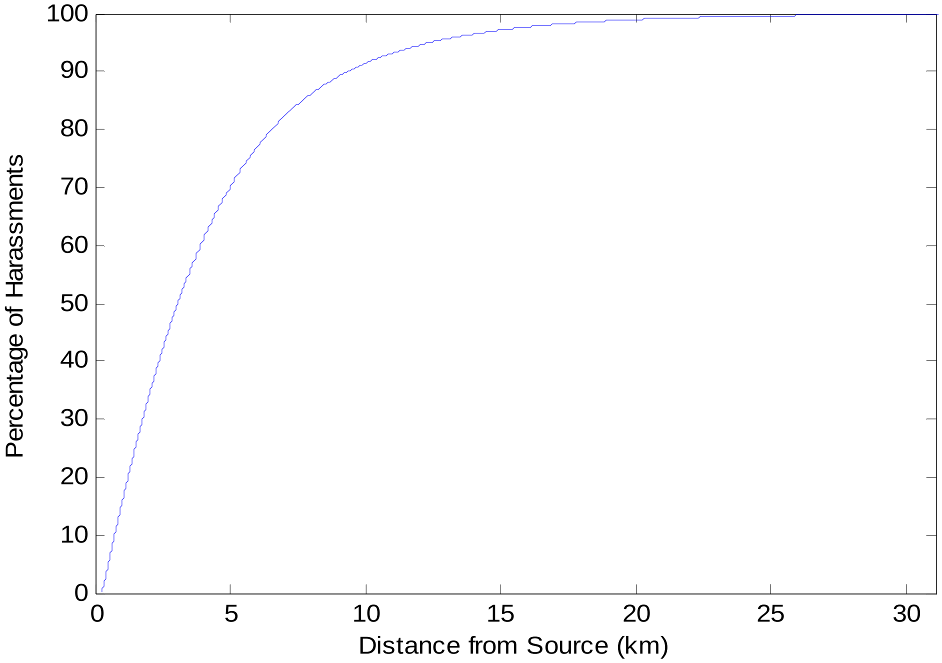


Figure B-28 – Average Percentage of Harassments Occurring Within a Given Distance during Summer Months

With the data used to produce the previous figure, the average effect reduction during summer months for a sound path blocked by land can be calculated. For the SQS-53, since approximately 92% of harassments occur within 10 km of the source, a sound path blocked by land at 10 km will, on average, cause approximately 92% of the effect of an unblocked path.

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 plot gives the land shadow reduction factor at each point in each range area for the SQS-53 (Figure B-29). 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 SQS-53 in the GOA is essentially 1, or the reduction in effect is 0% for both seasons. For the other, lower-power sources it follows that this reduction is also negligible.

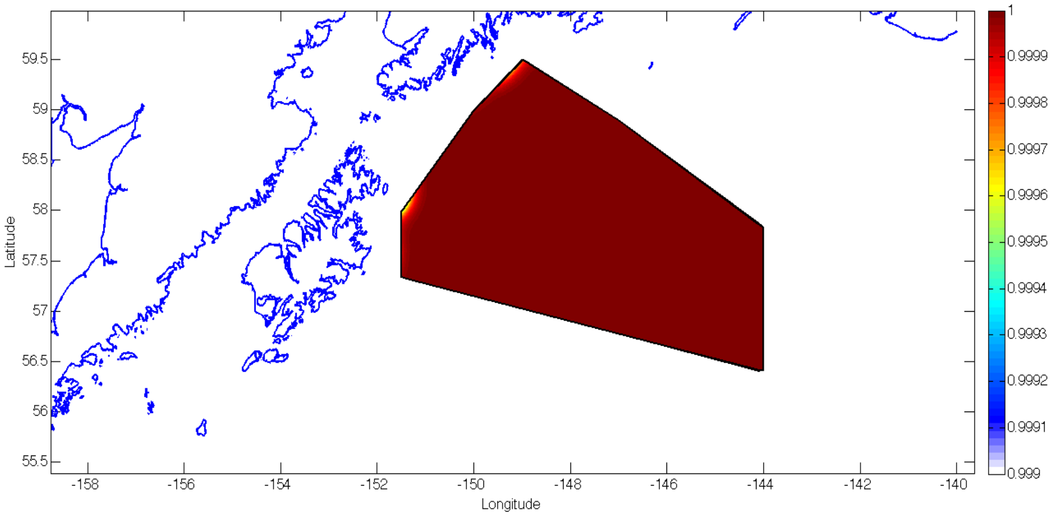


Figure B-29 – Depiction of Land Shadow in the MAA.

B.6.5.2 The Effect of Multiple Ships

Behavioral harassment, under dose response (risk function), uses maximum sound pressure level 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 sound pressure level 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 TMAA 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, in this case three ships.

The formation of ships in any of the above exercised has been determined by Navy planners. The ships are located in a straight line, perpendicular to the direction has traveled. The figures below (B-30 to B-34) show examples with four ships, and their ship tracks.

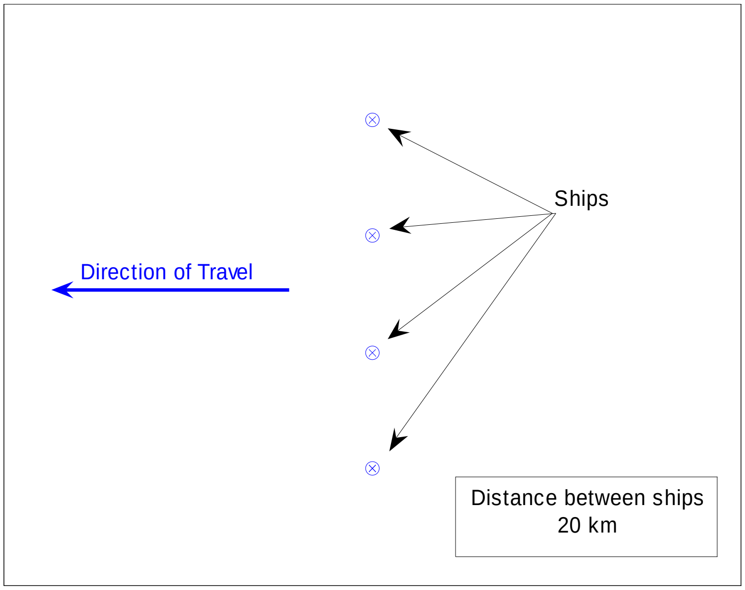


Figure B-30 – Formation and Bearing of Ships in 4-Ship Example

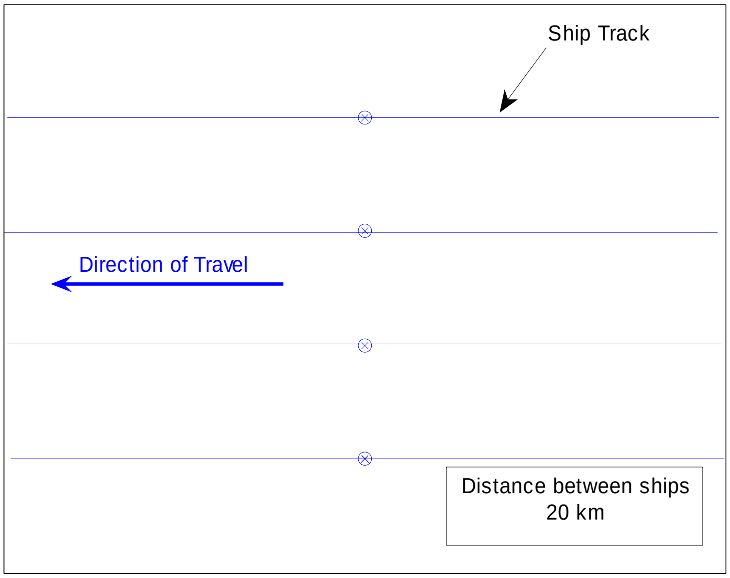


Figure B-31 – Ship Tracks of Ships in 4-Ship Example

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).

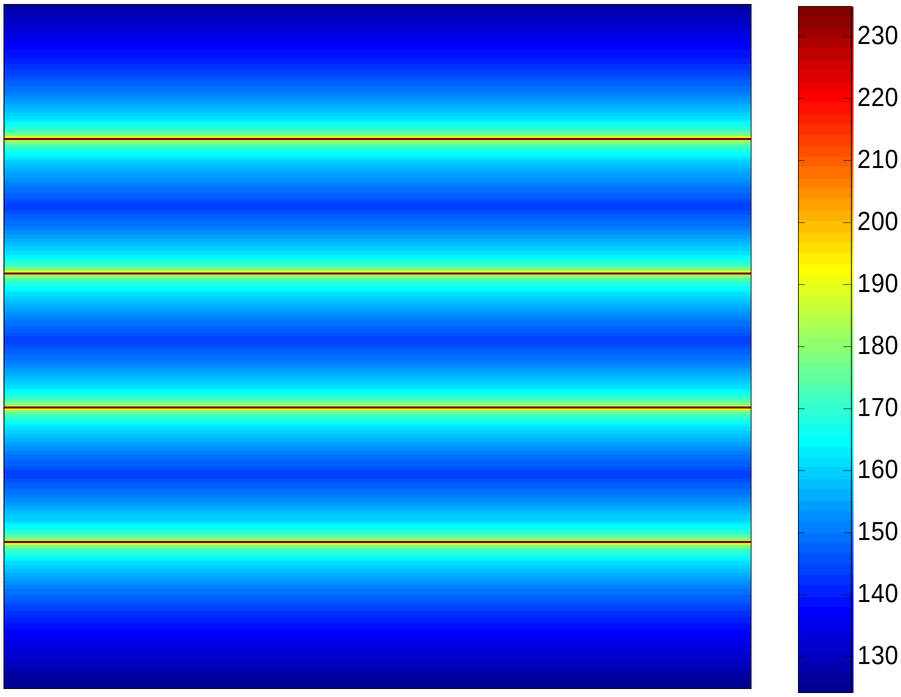


Figure B-32 – Sound Field Produced by Multiple Ships

This sound field of the four ships operating together (Figure B-32) ensonifies less area than four ships operating individually. However, because at the time of modeling, even the average number of ships and mean distances between them were unknown, a post-calculation correction should be applied.

As shown on Figure B-32, 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 (Figure B-33).

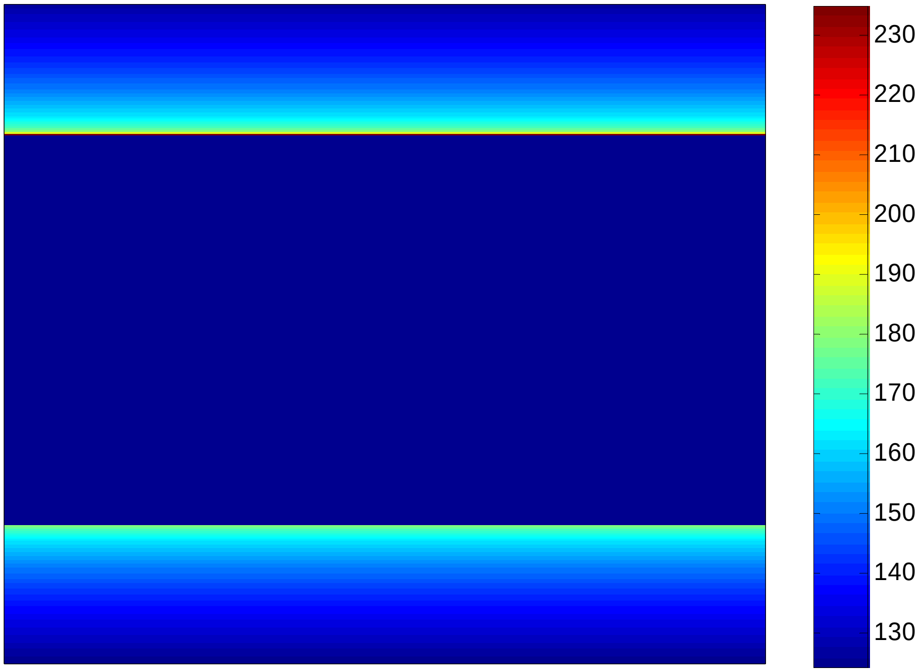


Figure B-33 – Upper and Lower Portion of Sound Field

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 B-34).

This remaining sound field is made up of three bands. 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 km distance between it and the next, the height of these bands is 20 km, and the sound from each side projects 10 km 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 km. The work in the previous discussion on land shadow provides a calculation of effect reduction for obstructed sound at each range. An SQS-53-transmitting ship with obstructed signal at 10 kilometers across both seasons causes an average of 95% of the number of harassments as a ship with an unobstructed signal. Therefore, each additional ship causes 0.95 times the harassments of the individual ship. Applying this single-ship factor to the exercise type described earlier (three ships), the adjustment factor given this formation is approximately 2.90.

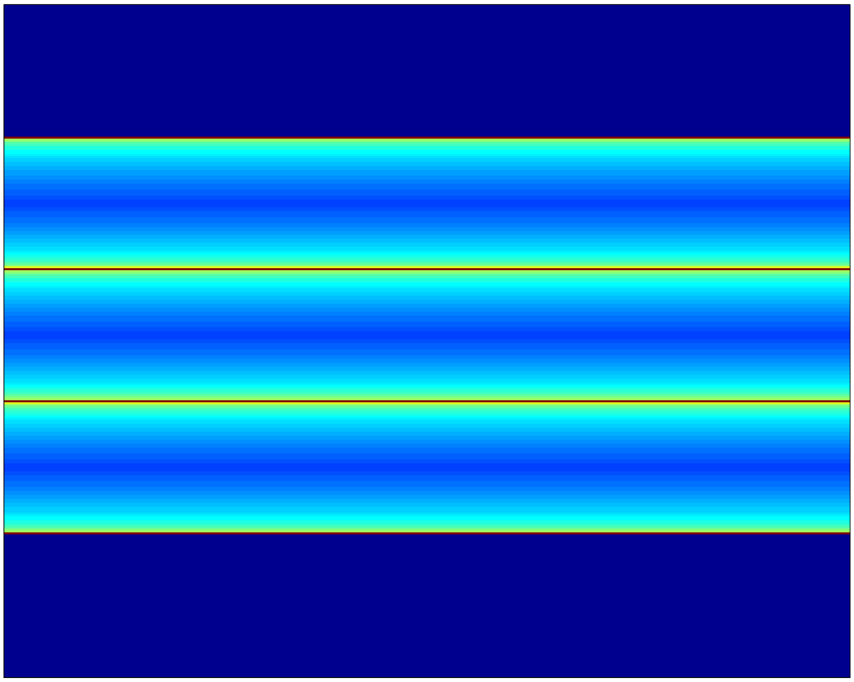


Figure B-34 – Central Portion of Sound Field

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Part 2 - Marine Mammal Density and Depth Distribution for the Gulf of Alaska (GOA) Maritime Activities Area

B.7 BACKGROUND AND OVERVIEW

Marine mammal species occurring in the Gulf of Alaska (GOA) and the GOA Temporary Maritime Activities Area (TMAA) include baleen whales (mysticetes), toothed whales (odontocetes), and seals and sea lions (commonly referred to as pinnipeds). 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.

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.

B.7.1 Density

Mysticetes regularly occurring in the GOA include fin, minke, humpback and gray whales; blue and North Pacific right whales have been sighted in the GOA, but are considered rare and are included here only for discussion purposes because both are endangered species. Odontocetes regularly occurring include sperm whale, Cuvier's and Baird's beaked whales, killer whale, Pacific white-sided dolphin and Dall's porpoise. Belugas are occasionally sighted in the GOA, but most sightings are in coastal areas and their occurrence in the region is extremely low. Pinnipeds regularly occurring include Steller's sea lion, northern fur seal and northern elephant seal. California sea lion range extends as far north as the Pribilof Islands in the Bering Sea but their occurrence is likely rare.

Recent survey data for marine mammals in the GOA is limited. Most survey efforts are localized and extremely near shore. There is evidence of occurrence of several species based on acoustic studies, but these do not provide measurements of abundance. Best available density data were incorporated from several different sources which are described below and summarized in Table B-16.

Fin and Humpback Whales

The Gulf of Alaska Line-Transect Survey (GOALS) was conducted in April 2009 (Rone et al. 2009) in the TMAA. Line-transect visual data and acoustic data were collected over a 10-day period, which resulted in sightings of several odontocete and mysticete species. Densities were derived for fin and humpback whales for inshore and offshore strata (Table 9 in Rone et al. 2009). Densities from each stratum were weighted by the percentage of stratum area compared to the TMAA: inshore stratum was 33% of the total area and offshore stratum was 67% of the total area.

Killer Whale

Vessel surveys were conducted in nearshore areas (within 85 km) of the TMAA in 2001-2003 (Zerbini et al. 2006), between Resurrection Bay on the Kenai Peninsula to Amchitka Island in the Aleutians. Densities were calculated for fin, humpback and killer whales; only those for killer whales are included here (Table B-16) because more recent densities for fin and humpback whales are available from Rone et al. (2009). Killer whale densities are from "Block 1" in Zerbini et al. (2006).

Minke, Sperm and Beaked Whales, Pacific White-sided Dolphin and Dall's Porpoise

Waite (2003) conducted vessel surveys for cetaceans near Kenai Peninsula, within Prince William Sound and around Kodiak Island, during acoustic-trawl surveys for pollock in summer 2003. Surveys extended offshore to the 1000 m contour and therefore overlapped with some of the TMAA. Waite (2003) did not calculate densities, but did provide some of the elements necessary for calculating density.

Barlow (2003) provided the following equation for calculating density:

$$\text{Density/km}^2 = \frac{(n)\,(s)\,(f_0)}{(2L)\,(g_0)}$$

Where (n) = number of animal group sightings on effort

(s) = mean group size

f(0) = sighting probability density at zero perpendicular distance (influenced by species detectability and sighting cues such as body size, blows and number of animals in a group)

(L) = transect length completed (km)

g(0) = probability of seeing a group directly on trackline (influenced by perception bias and availability bias)

Three values, n, s, and L, were provided by Waite (2003). Values for f(0) and g(0) were not provided, and were instead assigned based on values from the literature for other vessel survey efforts in the North Pacific (Table B-17). Using values calculated from other vessel survey efforts is acceptable in this situation because the correction factors were calculated from vessel surveys that were conducted similarly to the GOA effort. Specifically, factors such as number of observers (three), height of the flying bridge from the water's surface (12 m), ship's speed (11 kts), number of "Bigeyes" binoculars used (two), and acceptable sea state conditions (up to B05) during the GOA survey effort were all comparable to those used during NMFS survey efforts along the west coast of the US, in Hawaii and in the eastern tropical Pacific (see Table B-17). Values for f(0) and g(0) are very similar per species between efforts, therefore the most conservative value was adopted for each species and applied to the density calculation.

Table B-18 illustrates how the data from Waite (2003) were used to calculate densities using correction factors from Table B-17. There are no variances attached to any of the resulting density values, so overall confidence in these values is unknown. Densities based on only one or two sightings generally have fairly high variance.

Gray whales

Gray whale density was calculated from data obtained from a feeding study near Kodiak Island (Moore et al. (2007).

Steller Sea Lion, Northern Fur Seal and Northern Elephant Seal

Pinniped at-sea density is not often available because pinniped abundance is obtained via shore counts of animals at known rookeries and haulouts. Therefore, densities of pinnipeds were derived quite differently from those of cetaceans. Several parameters were identified from the literature, including area of stock occurrence, number of animals (which may vary seasonally) and season, and those parameters were then used to calculate density. Once density per "pinniped season" was determined, those values were prorated to fit the warm water (June-October) and cold water (November-May) seasons. Determining density in this manner is risky as the parameters used usually contain error (e.g., geographic range is not exactly known and needs to be estimated, abundance estimates usually have large variances) and, as is true of all density estimates, it assumes that animals are always distributed evenly within an area which is likely never true. However, this remains one of the few means available to determine at-sea density for pinnipeds.

The Marine Resource Assessment for the Gulf of Alaska Operating Area (DoN 2006), listed six mysticetes, twelve odontocetes, and five pinnipeds as occurring or possibly occurring in the GOA region (DON 2006, Table 3-1). However, several of the species listed are rare and do not regularly occur. Brief species summaries are included for all marine mammals whose distribution extends to the GOA, even if rarely seen, and additional information on all species can be found in the Marine Resources Assessment referenced above.

Table B-16 - Marine Mammals in the Gulf of Alaska; Densities and Season(s) Included for Species Regularly Seen.

Common Name	Scientific Name	Status	Density/km2 within TMAA	Season	Source
MYSTICETES					
Blue whale	*Balaenoptera musculus*	Endangered	-		
Fin whale	*B. physalus*	Endangered	0.010	Year round	Rone et al. (2009)
Sei whale	*B. borealis*	Endangered	-		
Minke whale	*B. acutorostrata*		0.0006	Year round	Waite (2003)
Humpback whale	*Megaptera novaeangliae*	Endangered	0.0019	Apr-Dec	Rone et al. (2009)
			-	Jan-Mar	Reeves et al. (2002)
North Pacific right whale	*Eubalaena japonica*	Endangered	-		
Gray whale	*Eschrichtius robustus*		0.0003	Year round	Moore et al. (2007)
ODONTOCETES					
Sperm whale	*Physeter catodon*	Endangered	0.0003	Year round	Waite (2003); Mellinger et al. (2004a)
Cuvier's beaked whale	*Ziphius cavirostris*		0.0022	Year round	Waite (2003)
Baird's beaked whale	*Berardius bairdii*		0.0005	Year round	Waite (2003)
Stejneger's beaked whale	*Mesoplodon stejnegeri*		-		
Killer whale	*Orcinus orca*		0.0100	Year round	Zerbini et al. (2007)
Beluga	*Delphinapterus leucas*		-		
Pacific white-sided dolphin	*Lagenorhynchus obliquidens*		0.0208	Year round	Waite (2003)
Northern right whale dolphin	*Lissodelphis borealis*		-		
Risso's dolphin	*Grampus griseus*		-		
False killer whale	*Pseudorca crassidens*		-		
Short-finned pilot whale	*Globicephala macrorhynchus*		-		
Dall's porpoise	*Phocoenoides dalli*		0.1892	Year round	Waite (2003)
Harbor porpoise	*Phocoena phocoena*		-		
PINNIPEDS					
Steller's sea lion	*Eumetopias jubatus*	Endangered/ Threatened	0.0098	Year round	Angliss and Allen (2009); Bonnell and Bowlby (1992)
California sea lion	*Zalophus californianus*		-		
Harbor seal	*Phoca vitulina*		-		
Northern fur seal	*Callorhinus ursinus*		0.1180	June-October	Carretta et al., 2009
Northern elephant seal	*Mirounga angustirostris*		0.0022	June-October	Carretta et al., 2009

Table B-17 - Comparison of f(0) and g(0) Values, for Species being Considered from Waite (2003) from Survey Efforts Outside of the TMAA.

Reference	Barlow (2003)		Ferguson and Barlow (2001)		Forney (2007)		Barlow and Forney (2007)		Barlow (2006)		Wade and Gerrodette (1993)
Species	f_0	g_0	f_0	g_0	f_0	g_0	f_0	g_0	f_0	g_0	f_0
Minke whale	**0.567**	**0.84**	0.362	0.84	0.38	0.856	0.46	0.856			
Sperm whale	0.217	**0.87**	**0.462**	0.87	0.36	0.87	0.34	0.87	0.27	0.87	0.14
Baird's beaked whale	0.354	**0.96**	0.215	0.96	0.37	0.96	**0.52**	0.96			
Cuvier's beaked whale	**0.567**	**0.23**	0.362	0.23	0.39	0.23	0.37	0.23	0.61	0.23	0.58
Pacific white-sided dolphin	**0.809**	1	0.519	1	0.4	**0.97**	0.45	0.97			
Dall's porpoise	**1.221**	**0.79**	0.855	0.79	0.74	0.822	0.91	0.822			
Survey region	US West Coast		US West Coast		US West Coast		US West Coast		Hawaii		Eastern Tropical Pacific
Number of observers	3		3		3		3		3		3
Speed of vessel (kts)	9-10		9-10		9-10		9-10		9-10		9-10
Height of flying bridge (m)	10.5		10.5		10.5 and 15.2		10.5 and 15.2		10.5		10.5
Big Eyes binoculars	two pair		two pair		two pair		two pair		two pair		two pair
Sea conditions	up to B05		up to B05		up to B05		up to B05		up to B05		up to B05

Conservative values for each species are bolded

Table B-18 - Densities Calculated from Data Presented in Waite (2003) using f(0) and g(0) Values from Table B-17.

Species	n = animal groups on effort[a]	s = mean group size[a]	L = transect length (km^2)[a]	f_0 = perpendicular sighting distance[b]	g_0 = probability of seeing group directly on trackline[b]	Density/km^2 = (n) (s) (f_0) / (2L) (g_0) [c]
Minke whale	3	1.3	2242	0.567	0.84	0.0006
Sperm whale	2	1.2	2242	0.462	0.87	0.0003
Baird's beaked whale	1	4	2242	0.52	0.96	0.0005
Cuvier's beaked whale	1	4	2242	0.567	0.23	0.0022
Pacific white-sided dolphin	2	56	2242	0.809	0.97	0.0208
Dall's porpoise	196	2.8	2242	1.221	0.79	0.1892

[a] from Waite (2003), [b] Values for f0 and g0 taken from Table 12, [c] Calculation taken from Barlow (2003).

There is no variance associated with these density calculations so there is no way to indicate the confidence in the value. Densities from sperm, Pacific white-sided, Baird's and Cuvier's beaked whales are quite weak as they are based on only 1-2 sightings.

B.7.2 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 when the animal returns to the beach. Depth information can also be collected via satellite tags, sonic tags, digital tags, and, for sperm whales, via acoustic tracking of sounds produced by the animal itself.

There are somewhat suitable depth distribution data for a few marine mammal species. Sample sizes are usually extremely small, nearly always fewer than 10 animals total and often only one or two 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 were extrapolated from similar species.

Depth distribution information for marine mammal species with regular occurrence and for which densities are available is provided in Table B-19. More detailed summary depth information for species in the GOA for which densities are available is included as Table B-21.

B.7.3 DENSITY AND DEPTH DISTRIBUTION COMBINED

Density is nearly always reported for an area, e.g., animals/km^2. Analyses of survey results using Distance Sampling techniques 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.

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 m) and others regularly diving to <200 m, regardless of the bottom depth. Therefore, assuming that all species are evenly distributed within the water column does not accurately reflect behavior and can present a distorted view of marine mammal distribution in any region.

By combining marine mammal density with depth distribution information, a more accurate three-dimensional density estimate is possible. These 3-D estimates allow more accurate modeling of potential marine mammal exposures from specific noise sources.

This document is organized into taxonomic categories: Mysticetes, Odontocetes and the pseudo-taxonomic category Pinnipeds. Nomenclature was adopted from the Integrated Taxonomic Information System (www.itis.gov). Distribution and density summaries are followed by discussions of depth distribution for those species that have regular occurrence. Density and depth info are **bolded** in text.

Table B-19 - Summary of marine mammal depth distributions for the TMAA

Common Name	Scientific Name	Depth Distribution	Reference
MYSTICETES - Baleen whales			
Fin whale	*B. physalus*	44% at <50m, 23% at 50-225m, 33% at >225m	Goldbogen et al. (2006)
Minke whale	*B. acutorostrata*	53% at <20m, 47% at 21-65m	Blix and Folkow (1995)
Humpback whale	*Megaptera novaeangliae*	37% at <4m, 25% at 4-20m, 7% at 21-35m,4% at 36-50m, 6% at 51-100m, 7% at 101-150m, 8% at 151-200m, 6% at 201-300m, <1% at >300m	Dietz et al. (2002)
Gray whale	*Eschrichtius robustus*	40% at <4 m, 38% at 4-30 m, 22% at >30 m	Malcolm et al. (1995/96); Malcolm and Duffus (2000)
ODONTOCETES - Toothed whales			
Sperm whale	*Physeter catodon*	31% at <10 m, 8% at 10-200 m, 9% at 201-400 m, 9% at 401-600 m, 9% at 601-800 m and 34% at >800 m	Amano and Yoshioka (2003)
Cuvier's beaked whale	*Ziphius cavirostris*	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% at >1070 m	Tyack et al. (2006)
Baird's beaked whale	*Berardius bairdii*	34% at 0-40 m, 39% at 41-800 m, 27% at >800 m	extrapolated from northern bottlenose whale (Hooker and Baird, 1999)
Killer whale	*Orcinus orca*	96% at 0-30 m, 4% at >30 m	Baird et al. (2003)
Pacific white-sided dolphin	*Lagenorhynchus obliquidens*	Daytime: 100% at 0-65 m; Nighttime: 100% at 0-130 m	extrapolated from other *Lagenorhynchus* (Mate et al., 1994; Benoit-Bird et al., 2004)
Dall's porpoise	*Phocoenoides dalli*	39% at <1 m, 8% at 1-10 m, 45% at 11-40 m, and 8% at >40 m	Hanson and Baird (1998)
PINNIPEDS			
Northern fur seal	*Callorhinus ursinus*	Daytime: 74% at <2 m; 26% at 2-260 m; Nighttime: 74% at <2 m; 26% at 2-75 m	Ponganis et al. (1992); Kooyman and Goebel (1986); Sterling and Ream (2004); Gentry et al. (1986)
Steller sea lion	*Eumetopias jubatus*	60% at 0-10 m, 22% at 11-20 m, 12% at 21-50 m, 5% at 51-100 m and 1% at >100 m	Merrick and Loughlin (1997)
Northern elephant seal	*Mirounga angustirostris*	9% at <2 m, 11% at 2-100 m, 11% at 101-200 m, 11% at 201-300 m, 11% at 301-400 m, 11% at 401-500 m and 36% at >500 m	Asaga et al. (1994)

B.8 MYSTICETES

B.8.1 Blue whale, *Balaenoptera musculus*

Blue whales were previously sighted and caught throughout the GOA, but are rarely seen in the post-whaling era; two blue whales seen in 2004 during a NMFS humpback whale study and approximately 150 nm southeast of Prince William Sound are the first documented sightings of blue whales in several decades. There may be two to five stocks of blue whale in the north Pacific (Angliss and Allen 2009). The Eastern North Pacific population, which winters as far south as the eastern tropical Pacific, has been sighted off Oregon and Washington although sightings are rare and there is no abundance estimate (Angliss and Allen 2009). Blue whale calls attributed to this stock as well as the Northwestern stock were recorded in the Gulf of Alaska (Stafford 2003) via hydrophones located offshore of the TMAA. Both call types were recorded seasonally, with peak occurrence from August-November. Blue whales are likely present in low numbers in the GOA; **there is no density estimate available (Table B-16)**.

B.8.2 Fin whale, *Balaenoptera physalus*

Fin whales were extensively hunted in coastal waters of Alaska as they congregated at feeding areas in the spring and summer (Mizroch et al. 2009). There has been little effort in the GOA since the cessation of whaling activities to assess abundance of large whale stocks. Fin whale calls have been recorded year-round in the GOA, but are most prevalent from August-February (Moore et al. 1998, 2006). Zerbini et al. (2006) sighted fin whales south of the Kenai Peninsula, and calculated a density of 0.008/km^2 (see Table 4, Block 1 in Zerbini et al. 2006). Waite (2003) recorded 55 fin whale sightings on effort, with several occurring within the TMAA (see Figure 2 in Waite 2003). Rone et al. (2009) recorded 24 sightings of 64 fin whales during a 10-day cruise in the TMAA in April 2009. Density for the inshore stratum was estimated as 0.012/km^2, while density in the offshore stratum was estimated as 0.009/km^2 (Table 9, Rone et al. 2009). **Combined density for the TMAA was 0.010/km^2, which is applicable to the entire region year round (Table B-16).**

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, Panigada et al. 2006), 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. Traveling dives in the Ligurian Sea were generally shorter and shallower (mean = 9.8 m, maximum = 20 m) than feeding dives (mean = 181m, maximum = 474 m) (Jahoda et al. 1999). Goldbogen et al. (2006) studied fin whales in southern California and found that ~56% of total time was spent diving, with the other 44% 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 are somewhat V-shaped although the bottom of the V is wide. **Therefore, % of time at depth levels is estimated as 44% at <50m, 23% at 50-225 m (covering the ascent and descent times) and 33% at >225 m.**

B.8.3 Sei whale, *Balaenoptera borealis*

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). They are known to occur in the GOA and as far north as the Bering Sea in the north Pacific. However, their distribution is poorly understood. The only stock estimate for U.S. waters is for the eastern north Pacific stock offshore California, Oregon and Washington (Carretta et al. 2009); abundance in Alaskan waters is unknown and they were not been sighted during recent surveys (Waite 2003, Rone et al. 2009). Sei whales are likely present in low numbers in the GOA; **there is no density estimate available (Table B-16)**.

B.8.4 Minke whale, *Balaenoptera acutorostrata*

Minke whales are the smallest of all mysticete whales. They are widely distributed in the north Atlantic and Pacific, and appear to undergo migration between warmer waters in winter and colder waters in summer. Minke whales can be found in near shore shallow waters and have been detected acoustically in offshore deep waters. There is no current abundance estimate for the Alaska stock of minke whales (Angliss and Allen 2009). Zerbini et al. (2006) sighted minke whales near Kodiak Island (and a single sighting nearshore off the Kenai Peninsula), and calculated a density of 0.006/km^2 (see Table 4, Block 3 in Zerbini et al. 2006). Waite (2003) recorded three minke sightings on effort, all southeast of the Kenai Peninsula (see Figure 2 in Waite 2003). Rone et al. (2009) sighted three minke whales in April 2009, all of which were in the Nearshore stratum, but no density was calculated. **Density calculated from Waite (2003) data yielded a density of 0.0006/km^2 (Table B-16), which is applicable to the entire region year round.** Although this is lower than density calculated by Zerbini et al. (2006), it is likely more representative of minke whale abundance in the region as the Waite (2003) surveys were farther offshore.

Minke whales feed on small schooling fish and krill, and are the smallest of all balaenopterid species which may affect their ability to dive. Hoelzel et al. (1989) observed minke whales feeding off the San Juan Islands of Puget Sound, Washington, where 80% of the feeding occurred over depths of 20-100m and two types of feeding were observed near surface, lunge feeding and bird association. 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.**

B.8.5 Humpback whale, *Megaptera novaeangliae*

Humpback whales are found in all oceans, in both coastal and continental waters as well as near seamounts and in 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 (e.g., Calambokidis et al. 2008). Humpbacks are highly migratory, feeding in summer at mid and high latitudes and calving and breeding in winter in tropical or subtropical waters. Humpbacks feeding in the TMAA in summer appear to winter in Hawaiian and Mexican waters (Calambokidis et al. 2008). Humpbacks are present in Alaskan waters during summer and fall, although there may be a few stragglers that remain year round. Waite (2003) recorded 41 humpback whale sightings on effort, with several occurring near shore around the Kenai Peninsula (see Figure 2 in Waite 2003). Rone et al. (2009) recorded 11 sightings of 20 individuals during a 10-day cruise in the TMAA in April 2009. Density for the inshore stratum was estimated as 0.004/km^2, while density in the offshore stratum was estimated as 0.0005/km^2 (Table 9, Rone et al. 2009). **Combined density for the TMAA was 0.0019/km^2, which is applicable to the entire region year round (Table B-16).** Calambokidis et al. (2008) estimated 3,000-5,000 humpbacks in the entire GOA, an area much larger than the TMAA.

Humpback whales feed on pelagic schooling euphausiids and small fish including capelin, herring and mackerel (Clapham 2002). Like other large mysticetes, they 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 open mouths 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 1987), while whales observed feeding on Stellwagen Bank in the North Atlantic dove to <40 m (Hain et al. 1995). Hamilton et al. (1997) tracked one possibly feeding whale near Bermuda to 240 m depth. 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% of time at 4-20 m, 7% of time at 21-35m, 4% of time at 36-50 m, 6% of time at 51-100 m, 7% of time at 101-150 m, 8% of time at 151-200 m, 6% of time at 201-300 m, and <1% at >300 m** (Dietz et al. 2002).

B.8.6 North Pacific right whale, *Eubalaena japonica*

North Pacific right whales were heavily hunted near Kodiak Island from the mid-1800s through the early 1900s. Despite international protection, the species has not recovered and remains one of the rarest of all cetaceans. There have been only two verified sightings of right whales in the GOA since the 1970s, with one occurring very near Kodiak Island (Shelden et al. 2005). Regular sightings of right whales do occur in the southeastern Bering Sea in summer, where up to 13 individual whales have been identified based on photos and biopsy dart data, but their winter habitat remains unknown. Acoustic monitoring for right whales was carried out via autonomous hydrophones in 2000-2001 near Kodiak Island, and right whale calls were recorded in August and early September (Moore et al. 2006, Mellinger et al. 2004b). Right whales are likely present in extremely low numbers in the GOA; **there is no density estimate available (Table B-16).**

B.8.7 Gray whale, *Eschrichtius robustus*

The current stock estimate for the eastern north Pacific stock of gray whales is 18,813 (Angliss and Allen 2009). Gray whales undertake a well-documented migration from winter calving lagoons in Baja California to summer feeding areas in the Bering and Chukchi seas (Swartz et al. 2006). Their migration route is primarily near shore in shallow water, although gray whales have been documented swimming offshore near the Channel Islands in the Southern California Bight. In addition to the Bering and Chukchi sea feeding areas, gray whales are known to feed opportunistically at several locations along the migratory route. Two such areas are near Ugak Bay, Kodiak Island, and along the outer coast of southeast Alaska where 30-50 gray whales have been sighted feeding year round (Moore et al. 2007). Gray whales would not be found in most of the TMAA but likely do cross the northernmost section (estimated at 2,400 km^2 via ArcMap and representing 2.75% of the total TMAA; 2,400 km^2/87,250 km^2 as measured in ArcMap) migrating to and from both local and distant feeding grounds. Rone et al. (2009) recorded three sightings of eight gray whales (see Figure 3 in Rone), which were located nearshore at Kodiak Island to the west of the TMAA and in the westernmost section of the TMAA on the continental shelf. The number of gray whales within the TMAA at any given time is likely quite small as it is probably at the deeper limit of their occurrence. Therefore, the lower estimate of Kodiak Island feeding gray whales from Moore et al. (2007) was used to estimate density. **Density was estimated at 0.0125/km^2 (30 gray whales/2,400 km^2) year round, and is applicable only for the farthest north area of the TMAA (2.75 % of area, see Figure B-35) for an overall density for the TMAA of 0.0003/km^2 (Table B-16).**

Gray whales migrate from breeding and calving grounds in Baja California to primary feeding grounds in the Bering and Chukchi Seas between Alaska and Russia. Behavior, including diving depth and frequency, can vary greatly between geographic regions. Gray whales feed on the bottom, mainly on benthic amphipods that are filtered from the sediment (Reeves et al. 2002), so dive depth is dependent on depth at location for foraging whales. There have been several studies of gray whale movement within the Baja lagoons (Harvey and Mate 1984, Mate and Harvey 1984), but these are likely not applicable to gray whales elsewhere. Mate and Urban Ramirez (2003) noted that 30 of 36 locations for a migratory gray whale with a satellite tag were in water <100m deep, with the deeper water locations all in the southern California Bight within the Channel Islands. There has been only one study of a gray whale dive profile, and all information was collected from a single animal that was foraging off the west coast of Vancouver Island (Malcolm and Duffus 2000, Malcolm et al.1995/96). They noted that the majority of time was spent near the surface on interventilation dives (<3 m depth) and near the bottom (extremely nearshore in a protected bay with mean dive depth of 18 m, range 14-22 m depth). There was very little time spent in the water column between surface and bottom. Foraging depth on summer feeding grounds is generally between 50-60 m (Jones and Swartz 2002). Based on this very limited information, **the following is a rough estimate of depth distribution for gray whales: 40% of time at <4 m (surface and interventilation dives), 38% of time at 3-30 m (active migration), 22% of time at >30 m (foraging).**

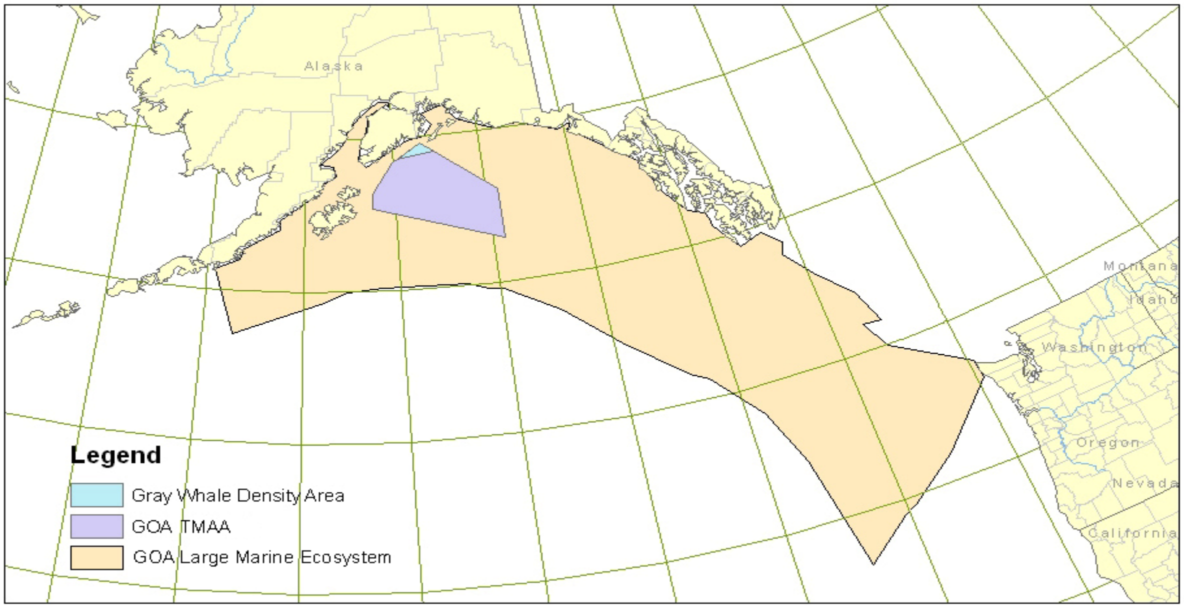

Figure B-35 - TMAA, GOA Large Marine Ecosystem and Gray Whale Density Area

B.9 ODONTOCETES

B.9.1 Sperm whale, *Physeter catodon*

Sperm whales are well known from the GOA region. 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). Acoustic evidence collected via autonomous recorders suggests that sperm whales are present in the offshore regions of the GOA year round (see Figure 2 in Mellinger et al. 2004a). Rone et al. (2009; Figure 8) recorded sperm whales acoustically in both the inshore and offshore strata of the TMAA in April 2009; no sperm whales were detected visually. Waite (2003) recorded two on-effort sightings of sperm whales; both within the TMAA (see Figure 2 in Waite 2003). **Data from vessel surveys conducted by Waite (2003) yielded a density of 0.0003/km^2 (Table B-16), which is applicable to the entire region year round.** Density was based on only two sightings, so confidence in the value is low, but it is the only density that exists at this time for the region.

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 (Whitehead 2002, Clarke 1986). Some evidence suggests that they 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 (>1000 m). The most consistent sperm whale dive type is U-shaped, during which 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. There is some evidence that male sperm whales, feeding at higher latitudes during summer months, may forage at several depths including <200 m, and utilize different strategies depending on position in the water column (Teloni et al. 2007). Perhaps the best source for depth distribution data comes from Amano and Yoshioka (2003), who attached a tag to a female sperm whale near Japan in an area where water depth was 1000-1500m. Based on values in Table 1 (in Amano and Yoskioka 2003) for dives with active bottom periods, the total 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 percentage 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 results from the duration of dive minus bottom time (37.4-17.5) or ~20 minutes. Assuming a fairly equal descent and ascent rate (as shown in Table 1 in Amano and Yoshioka) 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. The same is applied to 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.

B.9.2 Cuvier's beaked whale, *Ziphius cavirostris*

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 appear to prefer slope waters with steep depth gradients. There are no reliable population estimates for this species in Alaskan waters (Angliss and Allen 2009). **Data from vessel surveys conducted by Waite (2003) yielded a density of 0.0022/km^2 (Table B-16), which is applicable to the entire region year round.** Density was based on a single sighting, so confidence in the value is low, but it is the only density available for this region.

Cuvier's feed on mesopelagic or deep water benthic organisms, particularly squid (Heyning 2002). Stomach content analyses indicate 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 (>1000 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 >1000 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.**

B.9.3 Baird's beaked whale, *Berardius bairdii*

Baird's beaked whales, like most beaked whales, are a deep water species that inhabits the north Pacific. They generally occur close to shore only in areas with a narrow continental shelf. There is no reliable population estimate for this species in Alaskan waters (Angliss and Allen 2009). **Data from vessel surveys conducted by Waite (2003) yielded a density of 0.0005/km^2 (Table B-16), which is applicable to the entire region year round.** Density was based on a single sighting, so confidence in the value is low, but it is the only density available for this region.

There are no depth distribution data for this species. Studies conducted on the diet of Baird's from stomach content analysis reveal some insight into feeding patterns. Samples collected off the Pacific coast of Honshu, Japan, revealed a preference primarily for benthopelagic fish (87%) and cephalopods (13%), while samples collected in the southern Sea of Okhotsk were primarily cephalopods (Walker et al. 2002). Other stomach samples collected from same geographic regions indicated demersal fish were the most commonly identified prey, and that Baird's were feeding at the bottommost depths of at least 1000 m (Ohizumi et al. 2003). The overall dive behavior of this beaked whale is not known (e.g., shape of dive, interventilation dives, etc). In lieu of other information, the depth distribution for northern bottlenose whales, *Hyperoodon ampullatus,* will be extrapolated to Baird's. There has been one study on northern bottlenose whales, which provides some guidance as to depth distribution (Hooker and Baird 1999). Most (62-70%, average = 66%) of the time was spent diving (deeper than 40 m), and most dives were somewhat V-shaped. Both shallow dives (<400 m) and deep dives (>800 m) were recorded, and whales spent 24-30% (therefore, average of 27%) of dives at 85% maximum depth indicating they feed near the bottom. Using these data points, we **estimate 34% of time at 0-40 m, 39% at 41-800 m, 27% at >800 m for *H. ampullatus* and extrapolate this to *B. berardius*.**

B.9.4 Stejneger's beaked whale, *Mesoplodon stejnegeri*

Stejneger's beaked whale is known from the north Pacific only, ranging in subarctic and cool temperate waters. It is likely the only mesoplodont whale to be found in the GOA, as other *Mesoplodon* species do not range that far north. There is no abundance estimate for this species, as it is rarely seen at-sea and is most often recorded via stranding events (Angliss and Allen 2009). Stejneger's beaked whales are likely present in low numbers in the GOA; **there is no density estimate available (Table B-16)**.

B.9.5 Killer whale, *Orcinus orca*

There are two stocks of killer whales in the north Pacific whose ranges overlap in the GOA, but who differ in feeding preferences, acoustics and genetics. The Alaska Resident stock feeds primarily on fish, ranges from southeast Alaska to the Aleutian Islands and Bering Sea, and has a minimum population estimate of 1,123 based on photo ID (Angliss and Allen 2009). The Gulf of Alaska, Aleutian Islands and Bering Sea Transient stock feeds primarily on other marine mammals and ranges farther offshore in the GOA than the resident stock, as well as to the Aleutian Islands and Bering Sea. The minimum estimate based on photo ID for that population is 314. Vessel surveys for killer whales were conducted in July and August from 2001-2003 near Steller sea lion haulouts from the Kenai Peninsula to Amchitka Pass in the Aleutian Islands (Zerbini et al. 2007). The surveys did not venture far from shore but do provide density estimates for transient and resident stocks. **Survey blocks closest to the TMAA (blocks 2-5) had an average density of 0.010/km^2 resident killer whales (IGS density which the authors indicate is more appropriate for resident killer whales), which is applicable to the entire region year round (Table B-18).** Killer whales were seen and heard during a vessel cruise in the TMAA in April 2009 (Rone et al. 2009, Figures 4 and 8), but density was not calculated.

Diving studies on killer whales have been undertaken mainly on "resident" (fish-eating) killer whales in the 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. Using best available data from Baird et al. (2003), it would appear that **killer whales spend ~4% of time at depths >30 m and 96% of time at depths <30 m**. Dives to deeper depths were often characterized by velocity bursts which may be associated with foraging or social activities.

B.9.6 Beluga, *Delphinapterus leucas*

A genetically and geographically discrete population of belugas exists in Cook Inlet. Scattered sightings of belugas in the northern GOA have been recorded since the mid-1970s, and these animals may be part of the Cook Inlet stock (Laidre et al. 2000) or may be part of a group of belugas that appear to be resident to Yakutat Bay (O'Corry-Crowe et al. 2006). An in-depth review of 13 dedicated cetacean surveys in the GOA found that all northern GOA sightings were coastal and none were reported in offshore areas. **No density is available (Table B-16).**

B.9.7 Pacific white-sided dolphin, *Lagenorhychus obliquidens*

Pacific white-sided dolphins range throughout the north Pacific in cold temperate waters. Movements between inshore/offshore and north/south are not well understood. The north Pacific stock of this species, which ranges from British Columbia across the north Pacific and including the GOA, is currently estimated to have a minimum abundance of 26,880 based on data collected from 1987-90 (Angliss and Allen 2009). **Data from vessel surveys conducted by Waite (2003) yielded a density of 0.0208/km^2 (Table B-16), which is applicable to the entire region year round.** This density was based on just two sightings so confidence in this value is low, but it is the only density available for this region. Rone et al.

(2009) collected one sighting of 60 Pacific white-sided dolphins during the April 2009 cruise; the sighting was outside of the TMAA, south of Kodiak Island (See Figure 4 in Rone).

Pacific white-sided dolphins are generalist feeders (von Waerebeek and Wursig 2002). Studies on diving by this species have not been undertaken. Satellite tag studies of a rehabilitated related species (*Lagenorhynchus acutus*) in the Gulf of Maine indicated that nearly all time was spent in waters <100 m total depth with largely directed movement (Mate et al. 1994). Another related species, *Lagenorhynchus obscurus*, was observed feeding in two circumstances; at night to 130 m depth to take advantage of the deep scattering layer closer to the surface and during the day in shallower depths (<65 m) where they fed on schooling fish (Benoit-Bird et al. 2004). **In lieu of the lack of other data available for this Pacific lags, the following are very rough estimates of time at depth: daytime - 100% at 0-65 M; night time – 100% at 0-130 m.**

B.9.8 Northern right whale dolphin, *Lissodelphis borealis*

The northern right whale dolphin occurs in a band across the north Pacific, generally between 34˚ and 47˚N (Reeves et al. 2002). They are primarily an open ocean species, and rarely come near shore. Their presence in the GOA is unknown but, based on the lack of sightings of this gregarious species, is likely rare; **there is no density for this species (Table B-16)**.

B.9.9 Risso's dolphin, *Grampus griseus*

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). Their presence in the GOA is likely extremely rare and extralimital; **there is no density for this species (Table B-16).**

B.9.10 False killer whale, *Pseudorca crassidens*

False killer whales are found from tropical to warm temperate waters, with well known populations near Japan and in the eastern tropical Pacific. They were not seen along the Pacific US coast during surveys conducted from 1986-2001 (Ferguson and Barlow 2003, Barlow 2003) nor in 2005 (Forney 2007), although they have occasionally been sighted as far north as British Columbia (Reeves et al. 2002). Their presence in the GOA is likely extremely rare and extralimital; **there is no density for this species (Table B-16).**

B.9.11 Short-finned pilot whale, *Globicephala macrorhynchus*

This species is known from tropical and warm temperate waters and, in the northeast Pacific, its distribution likely extends as far north as Vancouver Island (Reeves et al. 2002). Pilot whales were not seen during vessel surveys conducted offshore Washington and Oregon in 1996 or 2001 (Barlow 2003) and there was only one sighting during surveys conducted in 2005 (Forney 2007). Their presence in the GOA is likely extremely rare and extralimital; **there is no density for this species (Table B-16).**

B.9.12 Dall's porpoise, *Phocoenoides dalli*

Dall's porpoises are endemic to the north Pacific, ranging north of ~32˚N into the Bering Sea. It is generally found in deep, cool waters but is also common in coastal areas. The Alaska stock is currently estimated at 83,400 animals (Angliss and Allen 2009). Waite (2003) sighted Dall's porpoise frequently throughout their study area, including several sightings south of the Kenai Peninsula and therefore within the TMAA. **Data from vessel surveys conducted by Waite (2003) yielded a density of 0.1892/km^2 (Table B-16), which is applicable to the entire region year round.** Rone et al. (2009; Figure 4) recorded 10 sightings of 59 Dall's porpoise in both the inshore and offshore strata, but density was not calculated.

Dall's porpoise feed on a wide variety of schooling fish, including herring and anchovies, mesopelagic fish including deep-sea smelts, and squids (a, 2002). One study of this species includes dive information for a single animal (Hanson and Baird 1998). The authors concluded that the animal responded to the TDR tag for the initial eight minutes it was in place. Therefore, using data only from dives 7-17 (after the abnormally deep high velocity dive) in Table 2 of Hanson and Baird (1998), total time of the sequence was 26.5 min (from start of dive 7 to end of dive 17). Total time at the surface was 10.27 min (time between dives minus the dive durations). Dives within 10 m totaled 2.11 min, dives to >60 m totaled 0.4 min, and dives with bottom time between 41 and 60 m totaled 1.83 min. The remaining time can be assumed to be spent diving between 11 and 40 m. **Based on this information, the depth distribution can be estimated as 39% at <1 m, 8% at 1-10 m, 45% at 11-40 m, and 8% at >40 m.**

B.9.13 Harbor porpoise, *Phocoena phocoena*

Harbor porpoise are found in coastal regions of northern temperate and subarctic waters (Reeves et al., 2002). To determine abundance of harbor porpoises in southern Alaska, Dahlheim et al. (2000) conducted aerial surveys from 1991-1993 only within 30 km of shore, based on data from Dohl et al. (1983) that indicated that harbor porpoise off California were almost exclusively within 0.25 nm of shore. Sightings around Kodiak Island were clustered in near shore bays on the north side of the island, with only two sightings up to 30 km offshore (see Figures 2 and 4 in Dahlheim et al. 2000). Harbor porpoise are generally not found in water deeper than 100 m, and decline linearly as depth increases (Carretta et al. 2001, Barlow 1988, Angliss and Allen 2009). A survey conducted in the GOA in June 2003 yielded a single sighting of two individuals (Waite 2003). The vessel survey conducted in April 2009 yielded 30 sightings of 89 harbor porpoise, most of which were outside of the TMAA (Rone et al. 2009, Figure 4). The coastal distribution and limitation to shallower depths make it likely that harbor porpoises would not be within the TMAA; **there is no density for this species (Table B-16)**.

B.10 PINNIPEDS

B.10.1 Steller's sea lion, Eumetopias jubatus

The range of the Steller's sea lion (SSL) crosses the north Pacific from Japan to northern California. This species does not undergo extensive migrations but will disperse widely during the non-breeding season. There are two US stocks, which are delineated based on location of rookeries. The Western US stock, listed as Endangered, encompasses SSL using rookeries west of 144˚W, and the Eastern US stock, listed as Threatened, include SSL whose rookeries are east of 144˚W. SSL from both stocks likely use the TMAA. Most SSL remain fairly close to rookeries and haulouts throughout the year, with adult females with pups averaging 17 km trip length in summer and 130 km trip length in winter; however foraging trips extended to >500 km offshore (Loughlin 2002, Merrick and Loughlin 1997) which encompasses the entire TMAA. Foraging trips are interspersed with time spent at haulouts throughout the year, and different age and sex classes molt at different times from late summer through early winter. Consequently, at any particular time during the year, at least some portion of the population will be at-sea. Call et al. (2007) found that the duration of at-sea and on-shore cycles of juvenile SSL differed between regions. In the Aleutian Islands and GOA, juvenile SSL departed at dusk and returned to haul out just prior to sunrise, while juvenile SSL in southeast Alaska departed throughout the day. Time of day departures and length of time at-sea are likely related to foraging opportunities and the distance/depth required for juveniles to travel finding food.

Pinniped at-sea density is not generally calculated because they are counted much more easily while on shore. Therefore, to determine densities of SSL in the TMAA, two sets of parameters need to be identified – the specific area and the number of animals. The area of the TMAA (measured in ArcMap) is ~87,250 km^2 (Figure 1). This represents 6.25% of the entire GOA Large Marine Ecosystem (LME) as defined by NOAA (www.lme.noaa.gov), and measured via ArcMap (~1,396,800 km^2, not including inland passages).

The GOA LME extends from the Alaska Peninsula in the west to the British Columbia-Washington border in the east. To determine the number of SSL in the GOA LME, the most recent counts of adult, juvenile and pup SSL at rookeries in the GOA (pups = 4,518, non-pups = 13,892; data from 2004-2005), southeast Alaska (n=20,793, data from 2005) and British Columbia (n=15,402, data from 2002) were combined for a total of 54,605 SSL (Angliss and Allen 2009). These are considered minimum counts, as they were not corrected for animals not counted because they were at sea. Bonnell and Bowlby (1992) estimated that 25% of the SSL sea lion population was feeding at sea at any given time. Therefore, 13,651 SSL (54,605 * 0.25) would be expected feeding at-sea in the GOA LME. To estimate the number within the TMAA, the number of SSL in the entire GOA (13,651) was multiplied by the percent area of the TMAA compared to the GOA LME (0.0625) for a total of 853 SSL. **Density was then calculated as 853 SSL/87,250 km^2, or 0.0098/km^2, which is applicable to the entire region year round (Table B-16).**

Acoustic modeling was calculated for two seasons, warm (June-October) and cold (November-May) water. Pinniped densities were therefore averaged to these two seasons by summing monthly densities and dividing by the number of months in each season (Table B-20). For Steller sea lions the warm and cold water densities are the same, as densities are expected to remain consistent throughout the year.

Steller sea lions feed on fishes and invertebrates, including walleye pollock, Pacific cod, mackerel, octopus, squid and herring (Loughlin 2002). Ongoing studies of SSL diving behavior have been conducted by NMFS in Alaska and Washington as part of an overall effort to determine why sea lion populations have been steadily declining (Merrick and Loughlin 1997, Loughlin et al. 2003). Tagging studies often focus on different age classes (weanling, young of year, adult female). Steller sea lion prey changes depending on the season, with some prey moving farther offshore in winter, which affects maximum depth. Females dived the longest and deepest, with young of the year and weanlings having lesser values for both categories (Call et al. 2007, Loughlin et al. 2003). Adult males generally disperse farthest (commonly 120 km but as far as 500 km) from haulouts (Raum-Suryan et al. 2004). Loughlin et al. (2003) recorded maximum dive depth of 328 m, although most dives were shallower. Some SSL appear to take advantage of vertically migrating prey, leaving haulouts at dusk and returning at dawn (Call et al. 2007) but other SSL appear to feed throughout daylight hours as well. Because all age classes may be in the water at any given time, the depth distribution was estimated from the proportion of dives per depth range for all age classes (Merrick and Loughlin 1997, Figures 4 and 2, respectively). **Based on this information, the depth distribution can be roughly estimated at 60% at 0-10 m, 22% at 11-20 m, 12% at 21-50 m, 5% at 51-100 m and 1% at >100 m.**

Table B-20 - Averaging of Stellers sea lion, Northern fur seal, and Northern elephant seal densities to fit warm (June-October) and cold (November-May) water seasons.

Species	***Stellers sea lion***	***Northern fur seal***	***Northern elephant seal***
Month	***Density***		
June	0.0098	0.1059	0.0000
July	0.0098	0.0000	0.0000
August	0.0098	0.0000	0.0000
September	0.0098	0.0072	0.0055
October	0.0098	0.4768	0.0055
Average Warm Season	**0.0098**	**0.1180**	**0.0022**
November	0.0098	0.4768	0.0055
December	0.0098	0.4768	0.0000
January	0.0098	0.0072	0.0000
February	0.0098	0.0072	0.0000
March	0.0098	0.0072	0.0055
April	0.0098	0.0072	0.0055
May	0.0098	0.1059	0.0000
Average Cold Season	**0.0098**	**0.1555**	**0.0024**

B.10.2 Northern fur seal, *Callorhinus ursinus*

The northern fur seal is endemic to the north Pacific. Breeding sites are located in the Pribilof Islands (up to 70% of the world population) and Bogoslof Island in the Bering Sea, Kuril and Commander Islands in the northwest Pacific, and San Miguel Island in the southern California Bight. Abundance of the Eastern Pacific Stock has been decreasing at the Pribilof Islands since the 1940s although increasing on Bogoslof Island. The stock is currently estimated to number 665,550 (Angliss and Allen 2009). The San Miguel Island Stock is much smaller, estimated at 9,424 (Carretta et al. 2009); this stock is believed to remain predominantly offshore California year round.

Males are present in the rookeries from around mid-May until August; females are present in the rookeries from mid-June to late-October. Nearly all fur seals from the Pribilof Island rookeries are foraging at sea from fall through late spring. Females and young males migrate through the Gulf of Alaska and feed primarily off the coasts of British Columbia, Washington, Oregon and California before migrating north to the rookeries (Ream et al. 2005). Immature males and females may remain in southern foraging areas year round until they are old enough to mate (National Marine Fisheries Service 2006). Adult males migrate only as far as the Gulf of Alaska or to the west off the Kuril Islands. Therefore, adult males (September-April), adult females (October-December; May-June) and all non-adult fur seals (October-December) can potentially be found in the TMAA depending on the time of year.

Counts conducted in 2004 of males at Pribilof Island rookeries yielded a total 9,978 (Table 2 in National Marine Fisheries Service 2006). Assuming an even distribution of fur seals throughout the GOA, and using a similar method as for other pinnipeds, the number of male fur seals was multiplied by the percent area of the TMAA compared to the GOA LME (0.0625) for a total of 624 fur seals. **Density was then calculated as 624 fur seals/87,250 km^2, or 0.0072/km^2, which is applicable for the entire region in September and January through April.** Because some northern fur seal adult males feed near the Kuril Islands, this density is likely an over-estimate.

To determine density for migration time periods when adult female, adult male and non-adult fur seals would be present in the TMAA while enroute to feeding areas (October-December), the total number of fur seals in the eastern Pacific stock (665,550) was multiplied by the percent area of the TMAA compared to the GOA LME (0.0625) for a total of 41,597 fur seals. **Density was then calculated as 41,597 fur seals/87,250 km^2, or 0.4768/km^2. This density is applicable for the entire TMAA for October-December.** Because this number includes pups of the year and first year mortality due to predation and other factors is very high, the density is very likely an over-estimate.

To account for migration time periods when adult females would be migrating north thru the TMAA enroute to the rookeries (May-June), the number of pups born (2006 Pribilof Islands and Bogoslof Island count= 147,900; Angliss and Allen 2009) was used to estimate the number of adult females (assuming all adult females birthed a pup). Assuming an even distribution of fur seal females as they migrate through the GOA, the number of female fur seals was multiplied by the percent area of the TMAA compared to the GOA LME (0.0625) for a total of 9,244 fur seals**. Density was then calculated as 9,244 fur seals/87,250 km^2, or 0.1059/km^2. This density is applicable for the entire** TMAA **for May-June.**

In most years, northern fur seals would not be expected in the GOA in July and August, because adults would still be in the rookeries and non-adults would be foraging farther south, so density would be zero.

Acoustic modeling was calculated for two seasons, warm (June-October) and cold (November-May) water. Northern fur seal densities were therefore averaged to these two seasons by summing monthly densities and dividing by the number of months in each season (Table B-20). **The warm water density for northern fur seals was 0.1180/km^2 and the cold water density was 0.1555/km^2 (see Table B-16), which are applicable to the entire area.**

Northern fur seals feed on small fish and squid in deep water and along the shelf break; deep dives occur on the shelf and feeding probably occurs near the bottom (Gentry 2002). There have been a few studies of this species' diving habits during feeding and migrating, although there is no information on dive depth distribution. Ponganis et al. (1992) identified two types of northern fur seal dives, shallow (<75 m) and deep (>75 m). Kooyman and Goebel (1986) found that the mean dive depth for seven tagged females was 68 m (range 32-150 m) and the mean maximum depth was 168 m (range 86-207). Sterling and Ream (2004) reported that the mean dive depth for 19 juvenile males was 17.5 m, with a maximum depth attained of 175 m. Diving was deeper in the daytime than during nighttime, perhaps reflecting the different distribution of prey (especially juvenile pollock), and also differed between inner-shelf, mid-shelf, outer-shelf and off-shelf locations. Deeper diving in the Sterling and Ream study tended to occur on-shelf, with shallower diving off-shelf. Diving patterns during migration tended to be shallower, with diving occurring mainly at night (indicating some feeding on vertically migrating prey) and most time during the day in the upper 5 m of the water column (Baker 2007). **Based on these very limited depth data, the following are very rough order estimates of time at depth: daytime: 74% at <2 m; 26% at 2-260 m; nighttime: 74% at <2 m; 26% at 2-75 m.**

B.10.3 California sea lion, *Zalophus californianus*

California sea lions breed in the Channel Islands in the southern California Bight and south into Baja California. Males will migrate after the breeding season north to near shore waters of Washington, Oregon and British Columbia (some immature males will remain in northern feeding areas year round). Females generally do not migrate as far north as males. California sea lions have been documented at several locations in Alaska (Maniscalco et al. 2004), including southeast Alaska, Kenai Peninsula and as far north and west at St. Paul Island in the Bering Sea. There were a total of 52 animals documented between 1963 and 2003, and they were observed during all seasons of the year. Their presence in the GOA Exercise Area is likely extremely low both due to the extralimital nature of the occurrence and the species preference for near shore habitat. **No density estimate is available (Table B-16).**

B.10.4 Northern elephant seal, *Mirounga angustirostris*

The California stock of elephant seals breeds at rookeries located along the California coast. The most recent population estimate (2005) was 124,000 animals, and was based primarily on pup counts and correction factors (Carretta et al. 2009). Only male elephant seals migrate as far north as the GOA during foraging trips, information known from extensive satellite tagging studies (LeBoeuf et al. 1986, 1993, 2000). Adult males are present at the California rookeries from December through February for mating, and again from May to August during molting. The number of males in the population is particularly difficult to estimate because all adult males are generally not present at the rookery at any one time.

Counts of males at rookeries in the Channel Islands and some central California sites in 2005 yielded 3,815 males and juveniles for which sex could not be determined. Some rookeries were not included in this estimate, including a rapidly growing rookery at Piedras Blancas, which in 2007 had an estimated population of 16,000 animals of all age and sex classes (www.elephantseal.org). The California elephant seal population has also been steadily increasing over time (Carretta et al. 2009). To account for males at rookeries not counted and an increase in the population since 2005, the number of males and juveniles reported in the 2009 stock assessment report (3,815) was doubled to 7,630. Using similar methods as described for Steller's, the number of male elephant seals (7,630) was multiplied by percent area of the TMAA compared to the GOA LME (0.0625) for a total of 477 elephant seals. **Density was then calculated as 475 seals/87,250 km^2, or 0.0055/km^2, which is applicable for the entire TMAA for March-April and September-November.** Because all elephant seal adult males are not at-sea at the same time, the density is probably an over-estimate.

As with northern fur seals, elephant seal densities were averaged to warm (June-October) and cold (November-May) water seasons to provide data suitable for acoustic modeling. To do so, monthly densities were summer and divided by the number of months in each season (Table B-20). **The warm water density for elephant seals was 0.0022/km^2 and the cold water density was 0.0023/km^2 (see Table B-16, which is applicable to the entire area).**

Elephant seals feed on deep-water squid and fish, and likely spend about 80% of their annual cycle at sea feeding (Hindell, 2002). There has been a disproportionate amount of research done in the diving capabilities of northern elephant seals. Breeding and molting beaches are all located in California and Baja California, and elephant seals are relatively easy to tag (compared to cetaceans) when they are hauled out on the beach; the tag package can be retrieved when the animal returns to shore rather than relying on finding it in the ocean. They are deep divers, and have been tracked to depths >1000 m, although mean depths are usually around 400-600 m. Elephant seals have more than one dive type, termed Types A-E, including rounded and squared-off U-shape, V-shape and others. Particular dive types appear to be used mainly during transit (Types A and B), "processing" of food (Type C), and foraging (Types D and E; Crocker et al. 1994). Asaga et al. (1994) collected dive information on three female seals and provided summary statistics for three dive types. Davis et al. (2001) recorded the diving behavior of a seal returning to the beach, and demonstrated transit depths averaging 186 m with range of depth from 8 m to 430 m. LeBoeuf et al. (1986, 1988), Stewart and DeLong (1993) and LeBoeuf (1994) provided histograms of dives per depth range for tagged females. LeBoeuf et al. (2000, 1988) and LeBoeuf (1994) provided details on foraging trips for males and females offshore California, including information on percentage of time at surface. Hassrick et al. (2007) noted that larger animals (adult males) exhibited longer bottom times and that surface swimming was not noted in the sixteen elephant seals that they tagged. Hindell (2002) noted that traveling likely takes place at depths >200m.

Even with this abundance of information, the numerous types of dives and lack of clear-cut depth distribution data means that the percentage of time at depth needs to be estimated. The closest information provided is from Asaga et al. (1994), which was used here. Note that this information is representative of type D foraging dives of female only. This is the type of dive that would be likely of an elephant seal at-sea. Summary stats from Table 17.3 (Asaga et al. 1994) were used; the data were collected from females only but will be applied to both sexes and all age classes due to lack of other concise data. Mean dive duration and mean surface intervals were added together to come up with total dive cycle in minutes. Amount of time to traverse from surface to bottom and bottom to surface was calculated by subtracting bottom time (given) from dive duration. Values for total cycle, surface interval, bottom time and descent/ascent were then averaged for all three females. Roundtrip surface to bottom and back averaged 12.9 minutes. Assuming a mean rate of descent/ascent over 527 m (average mean dive depth for all three females combined), the average rate per 100 m was 2.4 min. **Based on these averaged numbers, the following are estimates of time at depth: 9% at <2 m, 11% at 2-100 m, 11% at 101-200 m, 11% at 201-300 m, 11% at 301-400 m, 11% at 401-500 m and 36% at >500 m.**

B.10.5 Harbor seal, *Phoca vitulina*

Harbor seals are distributed throughout coastal areas of the North Pacific. Their distribution is largely tied to suitable beaches for hauling out, pupping and molting, and areas offering good foraging and protection from predators such as killer whales. Most harbor seals are non-migratory. Satellite-tracking studies of movements of adults and pups near Kodiak Island and elsewhere in the GOA indicate that mean distance between haul out and at-sea foraging was 10-25 km for juveniles and 5-10 km for adults (e.g., Lowry et al. 2001, Rehberg and Small 2001), and nearly all locations were in water <200 m deep, with an apparent preference for depths 20-100 m (Frost et al. 2001). The coastal distribution and limitation to shallower depths make it likely that harbor seals would not be within the TMAA; **there is no density for this species (Table B-16).**

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Table B-21 - Summary of Marine Mammal Depth and Diving Information for Species Found in the TMAA

NOTE: some species that are not endemic to GOA are included in this appendix because data on their depth and diving preferences were extrapolated to GOA species.

	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									
Fin whale	Planktonic crustaceans, including *Thyanoessa* sp and *Calanus* sp, as well as scholling 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. (2001); Acevado et al. (2002): Notarbartolo-di-Sciara et al. (2003); Bannister (2002); Johnston et al. (2005); Watkins and Schevill (1979)	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. (2001)
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. (2001)
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)
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 ascet 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 B-16 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 collumn, with peaks at 75 and 200-250 m.		Two whales/ September-October/ Time-depth-recorder	Croll et al. (2001)

	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**
Minke whale	Regionally dependent; can include euphausiids, copepods, small fish and squids; Japanese anchovy preferred in western North Pacific, capelin and krill in the Barents Sea; armhook squids in North Pacific	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); Konishi and Tamura (2007); Clarke (1986)	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)
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); Watkins and Schevill (1979)	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 B-18)	Ten Males/ February-April/ Time-depth-recorder	Baird et al. (2000); Helweg and Herman (1994)
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 (~1000 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	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 (1987); Dolphin (1988)

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Common Name	**Food Preference**	**Depth or Oceanic Preference**	**References**	**Behavioral State**	**Geographic Region**	**Depth Information**	**Depth Distribution**	**Sample Size/ Time of Year/Method**	**References**
Gray whale	Amphipods, including *Ampelisca* sp, and other organisms living in the sea floor; also occasionally surface skim and engulfing; dependent on location; euphausiids along frontal systems may also be important	Continental shelf, 4-120 m depth	Dunham and Duffus (2002); Jones and Swartz (2002); Bannister (2002); Yazvenko et al. (2007); Bluhm et al. (2007)	Migrating	Northeast Pacific (coastal Baja California to northern California)	30 of 36 locations in depths <100m deep (mean 39 m); consistent speed indicating directed movement		One whale/ February/ Satellite tag	Mate and Urban Ramirez (2003)
Gray whale				Feeding	Bering and Chukchi Seas	Depths at feeding locations from 5-51 m depth		Several whales/ July-November/ Aerial surveys and benthic sampling	Clarke et al. (1989); Clarke and Moore (2002); Moore et al. (2003)
Gray whale				Feeding	Northeast Pacific (Kodiak Island)	Feeding on cumacean invertebrates		Several whales/ Year-round/ Aerial surveys	Moore et al. (2007)
Gray whale				Feeding	Northeast Pacific (Vancouver Island)	Majority of time was spent near the surface on interventilation dives (<3 m depth) and near the bottom (extremely nearshore in a protected bay with mean dive depth of 18 m, range 14-22 m depth; little time spent in the water column between surface and bottom.	40% of time at <4 m (surface and interventilation dives), 38% of time at 3-18 m (active migration), 22% of time at >18 m (foraging).	One whale/ August/ Time-depth recorder	Malcolm et al. (1995/96); Malcolm and Duffus (2000)
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); Clarke (1986)	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)
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 (2000-4000 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)
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 1250-1500m; 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)

	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**
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)
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 1500-3000 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 B-16 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 B-16 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)
Sperm whale				Feeding	Gulf of Mexico	28% of total time was spent near surface (0-10m); foraging dive statistics provided in Table B-16 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 B-16 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)
Sperm whale				Feeding	North Pacific (Japan)	Diel differences in diving in one location offshore Japan, with deeper dives (mean 853 m) and faster swimming during the day than at night (mean 469 m); other location along Japan's coast showed no difference between day and night dives; most time (74%) spent on dives exceeding 200 m; surface periods of 2.9 h at least once per day; max depth recorded 1304 m		Ten whales/ May-June, October/ depth data loggers and VHF radio transmitters	Aoki et al. (2007)
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)

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Common Name	**Food Preference**	**Depth or Oceanic Preference**	**References**	**Behavioral State**	**Geographic Region**	**Depth Information**	**Depth Distribution**	**Sample Size/ Time of Year/Method**	**References**
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/ uknown/ stomach contents	Clarke and Young (1998)
Sperm whale				Occurrence	Mediterranean Sea (Alborian Sea south of Spain)	Preferred waters >700m		Vessel transects	Canadas et al. (2002)
Sperm whale				Feeding	Arctic Ocean (Norway)	Dives from 14-1860 m with median of 175 m; clicking (searching for prey) began at 14-218 m and stopped at 1-1114 m, and whale spent 91% of overall dives emitting clicks; shallower dives were apparently to target more sparse prey while deep dives led to frequent prey capture attempts and were likely within denser food layers		Four adult males/ July/ DTAG	Teloni et al. (2007)
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 (200-2000 m) or deeper	Heyning (2002); Santos et al. (2001); Blanco and Raga (2000); Clarke (1986)	Feeding	Northeast Pacific (Hawaii)	Max dive depth = 1450 m; identified at least three dive categories including inter-ventilation (<4 m, parabolic shape), long duration (>1000m, 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 taggin 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 B-17	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)
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)
Baird's beaked whale	Benthic fishes and cephalopods, also pelagic fish including mackerel and sardine; primarily squid off northern coast of Hokkaido and deep sea fish off Pacific coast of Japan	Deep waters over continental slope	Kasuya (2002); Kasuya (1986); Walker et al. (2002); Clarke (1986)	Feeding	Northwest Atlantic (Japan)	Whales caught at depths of ~1000 m; stomach contents included prey species normally found from 1100-1300 m; likely feeding at or near bottom		Several whales/ August-September/ Stomach contents	Ohizumi et al. (2003)
Northern bottlenose whale	Squid of genus *Gonatus* and *Taonius* and occasionally fish and benthic invertebrates	Deep waters >500 m; can dive to >1400 m	Gowans (2002); Kasuya (2002); Clarke and Kristensen (1980); Clarke (1986)	Feeding	Northeast Atlantic (Nova Scotia "Gully")	Most (62-70%, average = 66%) of the time was spent diving (deeper than 40 m); most dives somewhat V-shaped; shallow dives (<400 m) and deep dives (>800 m); whales spent 24-30% (therefore, average of 27%) of dives at 85% maximum depth indicating they feed near the bottom; deepest dive 1453 m; depth distribution taken from info in Table B-16	34% at 0-40 m, 39% at 41-800 m, 27% at >800 m	Two whales/ June-August/ Time-depth recorders	Hooker and Baird (1999)

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Common Name	**Food Preference**	**Depth or Oceanic Preference**	**References**	**Behavioral State**	**Geographic Region**	**Depth Information**	**Depth Distribution**	**Sample Size/ Time of Year/Method**	**References**
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 o fhigh 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 femalesl depth distribution info from Table 5 in Baird et al. (2003)	96% at 0-30 m; 4% at >30 m	Eight whales/ Summer-fall/ Time-depth recorders	Baird et al. (2005b); Baird et al. (2003)
Killer whale				Feeding	Southwest Atlantic (Brazil)	Small to medium-sized cephalopods, both offshore and coastal		Unknown animals/ unknown/ stomach contents	Santos and Haimovici (2001)
Killer whale				Feeding	North Pacific	Offshore type whales, likely fish eaters based on behavioral observations and stomach content analysis		Several/ Year round/ Observations and stomach contents	Dahlheim et al. (2008)
Pacific white-sided dolphin	Lanternfish, anchovies, hake and squid; also herring, salmon, cod, shrimp and capelin	Mostly pelagic and temperate; may syncrhonize movements with anchovy and other prey	van Waerebeek and Wursig (2002); Clarke (1986)	Feeding	Northeast Pacific (British Columbia inland waters)	Prey collected included herring, capelin, Pacific sardine and possibly eulachon		Unknown/ year round/ dipnet collection of prey	Morton (2000)
Atlantic white-sided dolphin	Herring, small mackerel, gadid fishes, smelts, hake, sand lances, squid; likely change from season to season	Continental shelf and slope from deep oceanic areas to occasionally coastal waters	Cipriano (2002); Clarke (1986)		North Atlantic (Gulf of Maine)	Most (89%) of time spent submerged; most (76%) dives were <1 min duration and none were for longer that 4 minute duration		One animal/ February/ satellite-monitored radio tag	Mate et al. (1994)
Atlantic white-sided dolphin				Feeding	North Atlantic (Ireland)	Most frequent prey were mackerel and silvery pout		Four animals/ year round/ stomach contents	Berrow and Rogan (1996)
White-beaked dolphin	Mesopelagic fish, especially cod, whiting and other gadids, and squid		Kinze (2002); Clarke (1986)	Feeding	North Atlantic (Ireland)	Stomach contained Gadoid fish and scad remains		One animal/ year round/ stomach contents	Berrow and Rogan (1996)
Dall's porpoise	Small schooling and mesopelagic fish and cephalopods	Deep offshore as well as deeper near shore waters; diurnal as well as nocturnal feeders to take advantage of prey availability	Jefferson (2002), Amano et al. (1998); Clarke (1986)	Travelling	North Pacific (Puget Sound)	Feasibility study to determine if Dall's could be successfully tagged with suction cup tag; depth distribution info from Table B-17 and excludes initial dive data when animal responded to tag event	39% at <1 m, 8% at 1-10 m, 45% at 11-40 m and 8% at >40 m	One animal/ August/ time-depth recorder	Hanson and Baird (1998)
PINNIPEDS									
Northern fur seal	Small fish and squid in deep water and along the shelf break; Pacific herring, squid and walleye pollock dominated in the Gulf of Alaska, British Columbia, Washington and Oregon; northern anchovy and squid primary in Oregon, Washington and California	Deep dives occur on the shelf and feeding probably occurs near the bottom	Gentry (2002); Ream et al. (2005)			Maximum dive depth 256 m		Two females/ July/ time-depth recorders	Ponganis et al. (1992)

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Northern fur seal				Feeding	North Pacific (Bering Sea)	Mean dive depth 68 m (range 32-150 m); mean maximum depth 168 m (range 86-207 m); two types of dives, shallow (<75 m; mean = 30 m; occur at night) and deep (>75 m; mean = 130 m; occur during day and night); total activity budget during feeding trips was 57% active at surface, 26% diving and 17% resting; depth distribution info from Gentry and others	Daytime: 74% at <2 m, 24% at 2-260 m; night time: 74% at <2 m, 24% at 2-75 m	Seven females/ July/ time-depth recorders	Gentry et al. (1986)
Northern fur seal				Feeding	North Pacific (Bering Sea)	Mean dive depth of 17.5 m, with a maximum depth of 175 m; diving deeper in the daytime than during nighttime, perhaps reflecting the different distribution of prey (especially juvenile pollock) that undertake night time vertical migrations, and also differed between inner-shelf, mid-shelf, outer-shelf and off-shelf locations; deeper diving tended to occur on-shelf, with shallower diving off-shelf.		19 juvenile males/ July-September/ satellite transmitters	Sterling and Ream (2004)
Northern fur seal				Feeding	North Pacific (Bering Sea to California)	Higher dive rates during night time hours compared with daytime; variation in mean dive depth between migratory travelling and destination area (eastern North Pacific coast) where meand dive depth was <25 m; night time mean dive depths were greater during full moon than during new moon		Three females/ November-May/ satellite transmitters	Ream et al. (2005)
Northern fur seal				Feeding	North Pacific (Bering Sea)	Activity budgets of lactating females of 44% locomoting, 23% diving and 33% resting at the surface		Four females/ August/ platform terminal transmitters	Insley et al. (2008)
Northern fur seal				Migrating	North Pacific (Bering Sea to Gulf of Alaska)	Diving behavior consistent regardless of habitat (pelagic or continental shelf); diving largely at night and in evening and morning with little diving during day suggesting feeding on vertically migrating prey	71% at <2 m, 14% at 2-5 m, 5% at 6-10 m, 6% at 11-25 m and 3% at 26-50 m	20 post-weaning pups/ November-May/ satellite-linked time-depth recorders	Baker (2007)
Steller sea lion	Fish, including walleye pollock, Pacific herring, sand lance, salmon, flounder, rockfish and cephalopods	Diets and feeding patterns change with seasons; population levels are related to prey with increasing populations correlated with diverse diets and decreasing populations correlated with diets of primarily one prey item; females feed mostly at night during breeding season; feeding occurs throughout the day during non-breeding season	Trites et al. (2007); Loughlin (2002); Merrick et al. (1994)	Feeding	North Pacific (southeast Alaska)	Characterized by relatively brief trips to sea that represent about on-half of total time, and by fairly frequent, short and shallow dives that occur mostly at night. Maximum depth recorded was 424 m; mean depth was 26.4 m, and 49% of all dives were <10 m.		13 females/ May-June, January/ satellite-linked time-depth recorders	Swain (1996)
Steller sea lion				Feeding	North Pacific (Gulf of Alaska)	Adult females forage close to land in summer (<20 km) and make brief trips (<2 days) and shallow dives (<30 m); in winter, divers are longer in distance (up to 300 km), time (up to several months) and deeper (>250 m), Average dive depth of 36.5 and 42.9 m		Two females/ unknown/ satellite-linked time-depth recorder	Merrick et al. (1994)

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Steller sea lion					North Pacific (Gulf of Alaska)	Adult females capable of foraging throughout GOA and Bering Sea, while young-of-year have smaller ranges and shallower dives; females in winter dove deepest (median 24 m, maximum >250 m, while young-of-year were shallowest (median 9 m, max 72 m); depth distribution taken from Figure 4 and represent averaging of all age/season classes	60% at 0-10 m, 22% at 11-20 m, 12% at 21-50 m, 5% at 51-100 m and 1% at >100 m.	15 animals/ June-July, November-March/ satellite-linked time-depth recorders and VHF transmitters	Merrick and Loughlin (1997)
Steller sea lion					North Pacific (Gulf of Alaska)	Young of year dove for shorter periods and shallower depths than yearlings; maximum dive depth was 288 m; long-range transits began at >10 months of age; depth distribution taken from Figure 2	78% in 0-10 m, 13% in 11-20 m, 7% in 21-50 m, and 2% in > 51 m	18 animals/ October-June/ satellite-linked time-depth recorders	Loughlin et al. (2003)
Steller sea lion					North Pacific (Washington)	Maximum dive depth was 328 m; depth distribution taken from Figure 2	28% in 0-10 m, 30% in 11-20 m, 18% in 21-50 m, 14% in 51-100 m and 10% in >100 m	Seven animals/ October-June/ satellite-linked time-depth recorders	Loughlin et al. (2003)
Steller sea lion					North Pacific (Gulf of Alaska)	Juveniles from western Alaska rookeries left on foraging trips at dusk and returned at dawn (taking advantage of polluck that vertically migrates and hauling out during the day), while juveniles from eastern Alaska rookeries left on foraging trips throughout the day and night, likely feeding on prey other than vertical migrants		129 animals/ August-November, January-May/ satellite dive recorders	Call et al. 2007)
Steller sea lion					North Pacific (Gulf of Alaska)	Round trip distance and duration of pups and juveniles increased with age, trip distance was greater for western rookeries than for eastern rookeries, trip duration was greater for females than males; 90% of trips were <=15 km from haul-outs; dispersals >500 km were undertaken only by males although dispersals of >120 km were common.		103 animals/ year round/ satellite dive recorders	Raum-Suryan et al. (2004)
Northern elephant seal	Feed on deep-water squid and fish, and likely spend about 80% of their annual cycle at sea feeding; feed in meso-pelagic zone on vertically migrating squid	Deeper waters (>1000 m); males farther north than females	Hindell (2002); Stewart and DeLong (1993; 1995); LeBoeuf et al. (1988); Asaga et al. (1994); LeBoeuf (1994)	Feeding	North Pacific	Dive continuously for 8-10 months/year; dispersion and migratory patterns related to oceanographic features and areas of biological productivity; primarily squid eaters; males travel farther than females; females submerged 91% and males submerged 88% of time at sea; dive continuously; average depth for females was 479 m (post-moult) and 518 m (post-breeding) and for males 364 m (post-breeding) and 366 m (post-moult)		36 adults (both sexes)/ February-August/ dive and location recorders	Stewart and Delong (1993)
Northern elephant seal				Feeding	North Pacific	seals use same foraging areas during post-breeding and post-moulting periods; sexes are segregated geographically		36 adults (both sexes)/ January-February; May; July/ geographic location time depth recorders	Stewart and DeLong (1995)
Northern elephant seal				Feeding	North Pacific	little time at depths <200 m or >800 m; post-breeding migration is directed northward and quick until feeding areas are obtained; dives in transit are shallower than those on foraging grounds		14 adults (both sexes)/ February-July/ geographic location time depth recorders	Stewart and DeLong (1994)

	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**
Northern elephant seal				Feeding	North Pacific	Sea surface temperature appears to influence female forage area choice; foraging occurred in near shore areas of Gulf of Alaska, offshore Gulf of Alaska, near shore off Washington and Oregon and offshore between 40 and 50 N		12 adult females/ year round/ time depth recorders	Simmins et al. (2007)
Northern elephant seal				Feeding	North Pacific	Post-lactation monitoring; 86% of time at-sea spent submerged; maximum dive of 894 m, but dives >700 m were rare; modal dive depths between 350 and 650 m; continuous deep diving while at-sea; night dives were more numerous, shallower and of shorter duration; most dives types D (deep and u-shaped)		Seven adult females/ February-March/ time-depth recorders	LeBoeuf et al. (1988)
Northern elephant seal				Feeding	North Pacific	Mean depth of dive 333 m; maximum dive 630 m; 6% of all dives <200 m		One adult female/ February/ time-depth recorder	LeBoeuf et al. (1986)
Northern elephant seal				Feeding	North Pacific	Differences in foraging locations and behavior between males and females; females exhibited pelagic diving with varying dive depths depending on prey location in deep scattering layer; males exhibited pelagic diving as well as flat-bottom benthic dives near continental margins; males migrated to northern Gulf of Alaska and eastern Aleutians with females distributed west to 150 W between 44 and 52 N		32 adults (both sexes)/ March-July/ radio-telemetry	LeBoeuf et al. (1993)
Northern elephant seal				Transiting	North Pacific	90% of time submerged; mean depth 289 m; directed swimming even while submerged used prolonged gliding during dive descents which reduces cost of transport and can increase the duration of the dive		One adult female/ April/ video and satellite telemetry	Davis et al. (2001)
Northern elephant seal				Feeding	North Pacific	Type D (foraging) dives account for 75-80% of all dives; type A (transit dives) rarely occurred in series; type C dives were shallowest; depth distribution information from table 17.3, type D dives which are foraging dives as they are the most common	9% at <2 m, 11% at 2-100 m, 11% at 101-200 m, 11% at 201-300 m, 11% at 301-400 m, 11% at 401-500 m and 36% at >500 m.	Two adult females/ February-May/ time-depth recorders	Asaga et al. (1994)
Northern elephant seal				Feeding	North Pacific	Transit dives in males cover large horizontal distances and are shallower than pelagic dive depths; transit dives in females and juveniles are both for transiting and search for prey patches; foraging dives have steeper angles than transit dives in females, but angles are not noticeably different in juveniles; swim speeds were similar across age and sex		16 animals (various ages)/ April-May/ time-depth recorders and platform terminal transmitters	Hassrick et al. (2007)
Northern elephant seal				Feeding	North Pacific	Males feed primarily from coastal Oregon to western Aleutian Islands, along continental margin and feed primarily on benthic organisms, migration is direct to forage areas across Pacific; females have wider foraging area from 38-60 N and from the coast to 172 E, and forage on pelagic prey in the water column, migration is more variable to take advantage of prey patches		47 adults (both sexes)/ March-June, September-December/ time-depth swim speed recorders	LeBoeuf et al. (2000)

	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**
Northern elephant seal				Feeding, Transiting	North Pacific	Different types of dives serve three general functions: type AB dives are transit dives (covering great horizontal distance and with shallow ascent and descent angles); type C dives are "processing" dives for internal processes such as digestions (slower swimming speed and short horizontal distance; type DE dives are foraging (both chasing prey pelagically and benthic foraging)		unknown	Crocker et al. (1994)