Northwest Training Range Complex

Environmental Impact Statement/ Overseas Environmental Impact Statement

Draft EIS/OEIS | December 2008
Volume 2

Commander
United States Pacific Fleet
c/o Pacific Fleet Environmental Office
1101 Tautog Circle
Silverdale, WA 98315

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4 CUMULATIVE IMPACTS

4.1 PRINCIPLES OF CUMULATIVE IMPACTS ANALYSIS

The approach taken to analyze cumulative impacts (or cumulative effects)[1] for the Proposed Action and Alternatives follows the objectives of the National Environmental Policy Act (NEPA) of 1969, Council on Environmental Quality (CEQ) regulations and CEQ guidance. CEQ regulations (40 Code of Federal Regulations [CFR] §§ 1500-1508) provide the implementing procedures for NEPA. The CEQ regulations define "cumulative effects" as:

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

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

This Environmental Impact Statement/Overseas Environmental Impact Statement (EIS/OEIS) will analyze the cumulative environmental effects of the Proposed Action and Alternatives by considering the following criteria:

- The area in which the effects of the proposed project will be felt;
- The impacts that are expected in the area from the proposed project;
- Other actions, past, present and reasonably foreseeable that have had or are expected to have impacts in the same area;
- The impacts or expected impacts from these other actions; and
- The overall impact that can be expected if the individual impacts are allowed to accumulate.

For the purposes of determining cumulative effects in this chapter, the Navy reviewed environmental documentation regarding known current and past Federal and non-Federal actions associated with the resources analyzed in Chapter 3. Additionally, projects in the planning phase were considered, including reasonably foreseeable (rather than speculative) actions that have the potential to interact with the

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

proposed Navy action. The level of information available for different projects varies. The best available science is used in this analysis.

4.1.1 Identifying Geographical Boundaries for Cumulative Impacts Analysis

Geographic boundaries for analyses of cumulative impacts in this Environmental Impact Statement/ Overseas Environmental Impact Statement (EIS/OEIS) vary for different resources and environmental media. For air quality, the potentially affected air quality regions are the appropriate boundaries for assessment of cumulative impacts from releases of pollutants into the atmosphere. For wide-ranging or migratory wildlife, specifically marine mammals and sea turtles, any impacts from the Proposed Action might combine with impacts from other sources within the range of the population. Therefore, identification of impacts elsewhere in the range of a potentially affected population is appropriate. Table 4-1 identifies the geographic scope of this cumulative impacts analysis, by resource area.

Table 4-1: Geographic Areas for Cumulative Impacts Analysis

Resource	Area for Impacts Analysis
Geology and Soils	Seaplane Base Survival Area, Seaplane Base Demolition Training Range (DTR), DTR Bangor, Navy Outlying Field (OLF) Coupeville, Indian Island
Air Quality	Puget Sound-Georgia Air Basin
Hazardous Materials and Hazardous Wastes	Offshore Area, Seaplane Base Survival Area, DTR Seaplane Base, DTR Bangor, Crescent Harbor, Indian Island, and Floral Point Underwater Explosive Ordnance Disposal (EOD) Training Ranges, OLF Coupeville, Darrington Area, and Military Operating Areas (MOAs)
Water Resources	Offshore Area, Seaplane Base Survival Area, DTR Seaplane Base, DTR Bangor, Crescent Harbor, Indian Island, and Floral Point Underwater EOD Training Ranges, and OLF Coupeville
Acoustic Environment – Airborne Sound	Offshore Area, Seaplane Base Survival Area, DTR Seaplane Base, DTR Bangor, Crescent Harbor, Indian Island, and Floral Point Underwater EOD Training Ranges, OLF Coupeville, Darrington Area, and MOAs
Marine Plants and Invertebrates, Fish, Sea Turtles, Marine Mammals, and Sea Birds	Offshore Area, Crescent Harbor, Indian Island, and Floral Point Underwater EOD Training Ranges
Terrestrial Biological Resources and Cultural Resources	Seaplane Base Survival Area, Seaplane Base Demolition Training Range (DTR), DTR Bangor, OLF Coupeville, Indian Island, Darrington Area, and MOAs
Traffic, Socioeconomics, Environmental Justice, and Public Safety	Offshore Area, Seaplane Base Survival Area, DTR Seaplane Base, DTR Bangor, Crescent Harbor, Indian Island, and Floral Point Underwater EOD Training Ranges, OLF Coupeville, Darrington Area, and MOAs

4.1.2 Projects and Other Activities Analyzed for Cumulative Impacts

4.1.2.1 Past, Present, and Reasonably Foreseeable Future Actions

Identifiable present effects of past actions are analyzed, to the extent they may be additive to impacts of the Proposed Action. In general, the Navy lists and/or analyzes the effects of individual past actions only where appropriate; cumulative impacts analysis typically focuses on aggregate effects of past actions. This depends on the availability of data and relevancy of the past effects. Although certain data (e.g., forest cover) may be available for extensive periods in the past (i.e., decades), other data (e.g. water quality) may be available only for much shorter periods. Because the data describing past conditions are usually scarce, the analysis of past effects is often qualitative (CEQ 1997). Also to be analyzed are all reasonably foreseeable future actions that may have impacts additive to the effects of the Proposed

Action. This includes all likely future development of the region even when foreseeable future action is not planned in sufficient detail to permit complete analysis (CEQ 1997). Table 4-2 and Table 4-3 present a summary of past, present, and planned projects with potential cumulative impacts implications.

Table 4-2: Past, Present, and Planned Future Projects in the Offshore Area

Project	Project Description	Project Timeframe		
		Past	Present	Future
OFFSHORE AREA				
Deep Sea Corals Study	Scientists from the National Center for Coastal Ocean Science and the Olympic Coast National Marine Sanctuary (OCNMS) have initiated a study of deep sea coral/sponge assemblages at the OCNMS and their potential vulnerability to anthropogenic activities in the area. The project began in June 2004 with a pilot survey. A follow-up survey was conducted from May 22 to June 4, 2006 to explore other areas of the sanctuary looking for communities of deepwater corals and sponges.	X	X	X
Washington Islands NWR Comprehensive Conservation Plan	In 2007, the USFWS completed a Final Comprehensive Conservation Plan to guide its management and resources within the Flattery Rocks NWR, Quillayute Needles NWR, and Copalis NWR over the next 15 years (USFWS 2005b).	X		
NAVSEA NUWC Keyport Range Extension – Quinault Underwater Tracking Range (QUTR)	In a Draft EIS/OEIS released to the public on September 12, 2008, the Navy proposes to extend the operational areas associated with the Naval Sea Systems Command (NAVSEA) Naval Undersea Warfare Center (NUWC) Keyport Range Complex. The Keyport Range Complex is composed of three geographically distinct range sites: the Keyport Range Site, Dabob Bay Range Complex (DBRC) Site, and the QUTR Site. The Keyport Range Site is not considered to have cumulative implications due to its location, geographically separated from any activities associated with the NWTRC. The DBRC is an inshore component of the extension and the QUTR is an offshore component. The Proposed Action would provide additional operating space at these range sites to better support current and evolving test requirements and range activities conducted by NUWC Keyport. The action would also include small increases in the average annual number of tests and days of testing at the QUTR Site. For purposes of cumulative impacts in the offshore area, only RDT&E activities are being analyzed at the QUTR.			X
Olympic Coast National Marine Sanctuary (OCNMS) Management Plan Update	The OCNMS is beginning a re-examination of management priorities. The OCNMS management plan was development in 1993 and is in need of updating. OCNMS is looking at the state of the sanctuary's resources and priorities and is requesting input from the public. OCNMS will be talking with the public over the next two to three years to decide on how to best manage and protect the sanctuary.			X

Table 4-3: Past, Present, and Planned Future Projects in the Inshore Area

Project	Project Description	Project Timeframe		
		Past	Present	Future
INSHORE AREA				
Naval Surface Warfare Center, Detachment Bremerton Command Consolidation	This action consolidates Naval Surface Warfare Center, Carderock Division Detachment Bremerton activities at Fox Island Laboratory and Detachment Bremerton to Naval Base Kitsap-Bangor in Silverdale, Washington. The project consists of constructing in-water facilities on Carlson Spit, including a new access pier and associated mooring components (e.g., dolphins, anchoring systems). In addition to the in-water facilities, a new structure is being constructed. Approximately 5 acres (2.0 ha) of mature forest are being removed to provide office and laboratory space. Construction of this project began in Spring 2007 with a project completion date scheduled for Fall 2008.		X	
Underwater Surveillance System	The Navy installed an active-acoustic Underwater Surveillance System within the designated Restricted Area at Naval Base Kitsap-Bangor. The purpose of this project was to improve the underwater detection capabilities at Naval Base Kitsap-Bangor to comply with current Navy directives regarding base security. The system operates at the same frequency and range as a commercial “fish finder” and is in operation full time. The system was installed and operational as of April 2006.	X		
Submarine Development Squadron FIVE Detachment Support Facilities	The Navy implemented upgrades to waterfront and shore-based support facilities for its Submarine Development Squadron FIVE Detachment at Submarine Base Bangor (now called Naval Base Kitsap-Bangor). These upgrades were completed in July 2005. Anticipated levels of mission support, and the operational tempo of assigned submarines, require additional shore-side buildings for administration, operations, industrial, and support functions.	X		
Fred Hill Materials Gravel Project	Fred Hill Materials, a materials supply firm based in Poulsbo, is proposing construction of a 4-mi (~6-km) conveyor belt connecting a 781-acre (316-ha) inland gravel mine to a 1,100-ft (335-m) long, 80-ft (24-m) high pier and 900-ft (274-m) long moorage dock. The shipping facility would be on the west shore of Hood Canal, 5 mi (8 km) south of the Highway 104 Hood Canal Bridge. When fully operational, the “pit to pier” operation would mine, transport, and ship an estimated 60,000 tons (54,432 metric tons) of gravel 24 hours per day, loading into barges and ships bound for domestic and foreign ports. Each vessel would travel under or through the opening of the floating Hood Canal Bridge. The company (action proponent) has begun the process of applying for permits. Under the Washington State Environmental Policy Act, an EIS public scoping meeting was held on September 27, 2007 and a Draft EIS is in progress.			X

Table 4-3: Past, Present, and Planned Future Projects in the Inshore Area (continued)

Project	Project Description	Project Timeframe		
		Past	Present	Future
Hood Canal Bridge East-half Replacement and West-half Retrofit Project	The eastern half of the Hood Canal Bridge, located between Kitsap and Jefferson counties at the northern mouth of Hood Canal, is nearing the end of its structural service life. An EA and Supplemental EA were prepared for the project and a FONSI issued in May 2002; construction began in 2006. When completed, the Hood Canal Bridge will have a new, wider, floating section, new approach sections, and transition trusses on the east and west ends. The east-half of the replacement is scheduled to be completed in summer 2009, and west-half retrofitting is scheduled to be completed by December 2010.		X	
Point Whitney Boat Ramp Upgrade	The Washington Department of Fish and Wildlife (WDFW) proposes to expand the existing public boat launch to better accommodate recreational boating access to Dabob Bay. The existing 10-ft (3-m) wide ramp would be widened to 12 ft (4 m) and extended 22 ft (7 m) beyond the end of the existing ramp to a total length of 132 ft (40 m). Potential impacts were identified for Pacific herring and epibenthic organisms and infauna that utilize eelgrass habitat in the boat ramp area. Mitigation measures were outlined in the Final State Environmental Policy Act (SEPA) documentation, dated November 3, 2004, and an addendum to Determination of Non-Significance was signed on September 15, 2005.			X
Hood Canal Dissolved Oxygen Program	The Hood Canal Dissolved Oxygen Program was created to address the historically low DO situation and the effect on marine life. The Program is a partnership of 28 organizations that works with local, state, federal, and Tribal government policy makers to evaluate potential corrective actions that will restore and maintain DO to reduce stress to marine life. A three-year Integrated Assessment and Modeling Study was conducted from 2005-2007 to use marine, freshwater and biota monitoring data and a computer model to quantify the role the various natural processes and human actions are playing to control the concentrations of DO in Hood Canal and to test corrective action scenarios.	X	X	X
Waterfront Restricted Area (WRA) Land/Water Interface (LWI), Naval Base Kitsap-Bangor	This project is to provide security upgrades to the existing Naval Base Kitsap-Bangor WRA by constructing two WRA LWI Barriers, which connect both ends of the WRA enclave to the existing floating barriers. The LWIs will extend from the high water mark to the terminations of the Port Security Barriers (PSB) and will be capable of moving in the full tide range and providing an anchorage for the floating barriers. The project consists of two separate construction features. This project is scheduled to occur in FY12.			X

Table 4-3: Past, Present, and Planned Future Projects in the Inshore Area (continued)

Project	Project Description	Project Timeframe		
		Past	Present	Future
Jefferson County Black Point Master Planned Resort	The Statesman Group of Companies, LTD, and Black Point Properties, LLC, have submitted an application for a Master Planned Resort in the Black Point area called the Pleasant Harbor Marina and Golf Resort on the shore and uplands near Brinnon and the Navy Range at Dabob Bay. The project consists of 253 acres (102 ha), a marina with 290 slips, minor commercial facilities, an 18-hole golf course, and 1,090 residential units designed to serve the visiting public through a "condotel" program, with individual units privately owned but managed as a resort. Also at issue is the likelihood of the resort exchanging property with the Department of Fisheries to enable the construction of a new boat ramp, which would be open to the public. The document addressed potential impacts to shellfishing, water quality, transportation, public services, shorelines, fish and wildlife, rural character, archaeological and cultural resources, and critical areas. A FEIS was published in November 2007 and was included as part of the 2007 Comprehensive Plan Amendment Cycle. The Board of County Commissioners approved the proposal in January 2008.			X
Swimmer Interdiction Security System, naval Base Kitsap-Bangor	The U.S. Navy has proposed to implement a Swimmer Interdiction Security System to meet special U.S. government security requirements for military installations in response to the terrorist attacks of September 11, 2001. The system would protect waterside Navy assets and sailors and would remain in operation as long as valuable naval assets are located at Naval Base Kitsap-Bangor. The Navy examined various alternatives for implementing the system: marine mammals (preferred alternative), combat swimmers, and remotely operated vehicles (ROVs). Under the preferred alternative, specially trained marine mammals and their human teammates would respond rapidly to security alerts by detecting, classifying, and marking the location of underwater objects or interdicting intruders. Humans would work aboard small power boats and marine mammals would be in enclosures. A Draft EIS is currently being prepared and is expected to be available to the public for comment in Fall 2008, with a Record of Decision anticipated for Spring 2009.			X
NAVSEA NUWC Keyport Range Extension – DBRC Site	Refer to the description provided under the offshore projects for the NAVSEA NUWC Keyport Range Extension – QUTR Site. The Proposed Action would provide additional operating space at the DBRC range site to better support current and evolving test requirements and range activities conducted by NUWC Keyport. The action would also include small increases in the average annual number of tests conducted at the site. For purposes of cumulative impacts in the inshore area, only RDT&E activities are being analyzed at the DBRC Site. This Draft EIS/OEIS was released to the public on September 12, 2008.			X

Table 4-3: Past, Present, and Planned Future Projects in the Inshore Area (continued)

Project	Project Description	Project Timeframe		
		Past	Present	Future
Transit Protection System Facilities, Naval Base Kitsap-Bangor	This project is to provide berthing for three types of Transit Protection System vessels and various Port Operations tugs and small craft. In addition, the project will provide the necessary support facilities ashore for the command, administrative, operations, and support functions of the crews and command personnel of associated escort vessels and craft. The project involves the demolition of an existing pier and the installation of piles for the new pier, as well as construction of new facilities. The pier will be located at the site of the existing Magnetic Silencing Facility (MSF). The existing MSF and associated support facilities will be demolished. The proposed development involves several potentially significant issues, including endangered and threatened species, stormwater runoff, demolition material disposal, and the avoidance of impacts to valuable upland natural resources. This project is scheduled to occur in FY11.			X
P-8A Multi-Mission Aircraft (MMA)	The Navy is preparing an EIS for to provide facilities and functions to support the homebasing of 12 P-8A MMA squadrons and one fleet replacement squadron at established maritime patrol homebases. The P-8A would replace the P-3C aircraft. Currently, P-3C patrol squadrons are based at Naval Air Station (NAS) Jacksonville, Florida; NAS Whidbey Island; NAS Brunswick, Maine; and Marine Corps Base Hawaii Kaneohe Bay, with periodic detachments at NAS North Island, California. Under the preferred alternative, four P-8A MMA fleet squadrons would be homebased at NAS Whidbey Island. The transition would begin no later than 2012 and be complete in 2019.			X
EA-18G Growler	The EA-18G Growler is an Airborne Electronic Attack (AEA) aircraft which operates from either an aircraft carrier or from land-bases. The Growler has been developed as a replacement for the United States Navy EA-6B Prowler aircraft which entered service in 1971 and is approaching the end of operational life. The EA-18G Growler fleet will be based at Naval Air Station Whidbey Island, Washington. The transition is under way and is expected to be completed by 2013.			X
The Crescent Bay Salt Marsh and Salmon Restoration Project	The Restoration Project will restore 200 acres of juvenile salmon rearing habitat and other wetland functions to the Crescent Bay marsh, once the largest open barrier island salt marsh (approximately 300 acres) on Whidbey Island in Puget Sound. The restoration site is located on Naval Air Station Whidbey Island. The initial phase of the project includes baseline ecological assessment, restoration design, construction, and one year of post-construction monitoring. A second phase will cover implementation of 10 years of post-construction monitoring and adaptive management.			X

4.1.3 Other Activities

In addition to analyzing past, present, and planned future projects as listed in Table 4-2, following is a description of other activities that were also considered as part of the cumulative impact analysis.

4.1.3.1 Fishing

Commercial and recreational fishing constitutes a significant non-military use of the ocean areas of the NWTRC. As discussed in Section 3.7, the Pacific Fisheries Information Network (PacFIN) maintains commercial catch block data for ocean areas off the coasts of Washington, Oregon, California, Alaska, and British Columbia (PacFIN 2008). The annual catch of fish and invertebrates within Washington waters for 2007 amounted to approximately 180,221,946 pounds (see Table 3.14-1). Within the NWTRC OPAREA, groundfish species encompass the majority of the commercial catch. Groundfish species are categorized in the following groups: flatfish, rockfish, thornyheads, scorpionfish, roundfish, skates, sharks, and chimaeras. Pelagic species are managed under the Coastal Pelagic Species FMP and include several species within six families (anchovies, jacks, herrings, mackerals, squids, and krill). Salmonid species with known or potential occurrence within the NWTRC include five species of Pacific salmon: the chinook, chum, coho, pink, and sockeye; and three species of trout: the cutthroat, steelhead, and bull. For the 2007 annual catch, groundfish accounted for 65.7 percent, pelagic species accounted for approximately 18.7 percent, and Salmon accounted for 14.98 percent (Refer to Table 3.14-1 for detailed list). Other commercial fishing targets include crustaceans (Dungeness crab and shrimp) geoduck, squid, urchins, and other invertebrates.

Fishing can adversely affect fish habitat and managed species. Potential impacts of commercial fishing include over-fishing of targeted species and by-catch, both of which negatively affect fish stocks. Mobile fishing gears such as bottom trawls disturb the seafloor and reduce structural complexity. Indirect effects of trawls include increased turbidity, alteration of surface sediment, removal of prey (leading to declines in predator abundance), removal of predators, ghost fishing (i.e., lost fishing gear continuing to ensnare fish and other marine animals), and generation of marine debris. Lost gill nets, purse seines, and long-lines may foul and disrupt bottom habitats. Recreational fishing also has the potential to affect fish habitats because of the large number of participants and the intense, concentrated use of specific habitats.

Removal of fish by fishing can have a profound influence on individual populations. In a recent study of retrospective data, Jackson et al. (2001) analyzed paleoecological records of marine sediments from 125,000 years ago to present, archaeological records from 10,000 years before the present, historical documents, and ecological records from scientific literature sources over the past century. Examining this longer term data and information, they concluded that ecological extinction caused by overfishing precedes all other pervasive human disturbance to coastal ecosystems including pollution and anthropogenic climatic change.

Natural stresses include storms and climate-based environmental shifts, such as algal blooms and hypoxia. Disturbance from ship traffic and exposure to biotoxins and anthropogenic contaminants may stress animals, weakening their immune systems, and making them vulnerable to parasites and diseases that would not normally compromise natural activities or be fatal.

4.1.3.2 Commercial and Recreational Marine Traffic

A significant amount of ocean traffic, consisting of both large and small vessels, transits through the NWTRC. Washington State handles seven percent of the country's exports and six percent of its imports. Seattle and Tacoma were ranked seventh and tenth, respectively, among U.S. ports with respect to total cargo imported and exported in 2005 (http://www.bts.gov). Taken together, these two ports comprise the nation's third largest "container load center" in the U.S., second only to Los Angeles/Long Beach and New York/New Jersey (www.washingtonports.org). The Ports of Seattle and Tacoma are also an important commercial cargo port. Cruise ships make daily use of Seattle port facilities as well. For commercial vessels, the major trans-oceanic routes transit west from the Puget Sound area bypassing W-

237 or entering the area briefly to the north. Ships also travel southwest to Hawaii entering the warning area briefly to transit (Figure 3.13-2). The approach and departure routes into the Puget Sound can be adjusted depending on Navy activities notification through Notice to Mariners (NOTMARs).

Commercial vessels are sources of pollutants introduced into the waters and air basin of the PSGB. Additionally, commercial vessels are a source of ship strikes on marine mammals, and are implicated in many ship strikes in the PACNW. (Information about ship strikes and other marine mammal stranding events, and about introduction of pollutants into the coastal waters, is provided below).

A very substantial volume of small craft traffic, primarily recreational, occurs throughout the PACNW. Puget Sound has 244 marinas with 39,400 moorage slips and another 331 launch sites for smaller boats (Washington Department of Ecology 2006). Statewide, approximately 180,000 boats are registered, not counting thousands more small boats and watercraft that do not require registration. Because pleasure boats are sources of fuel leaks and toxins from antifouling paints, they constitute a potential environmental concern that has not been quantified. (Information about pollutants and hazardous wastes introduced into the PACNW waters is provided below).

4.1.3.3 Wave/Tidal Energy Plants

In addition to its abundant solar, wind and geothermal resources, the PACNW is also uniquely situated to capture the renewable energy of the ocean. Special buoys, turbines, and other technologies can capture the power of waves and tides and convert it into clean, pollution-free electricity. Like other renewable resources, both wave and tidal energy are variable in nature. Waves are produced by winds blowing across the surface of the ocean. However, because waves travel across the ocean, their arrival time at the wave power facility may be more predictable than wind. In contrast, tidal energy, which is driven by the gravitational pull of the moon and sun, is predictable centuries in advance.

The technologies needed to generate electricity from wave and tidal energy are at a nascent stage, but the first commercial projects are currently under development, including some in the PACNW. Along the Washington coast, offshore from the Makah Indian Reservation a pilot site was established by Thales GeoSolutions (Pacific), Inc. in 2002 to assess the seabed for a possible site for a wave energy park. This permit application with the Federal Energy Regulatory Commission has recently been withdrawn (DJC 2008). Three other permits have been approved by the Federal Energy Regulatory Commission since 2007. Further south on the Oregon Coast, the Coos Bay Offshore Wave Power Plant is also being evaluated for site consideration (NYT 2007). Like most emerging energy technologies, wave and tidal technologies are currently more expensive than traditional generating resources, but with further experience in the field, adequate R&D funding, and proactive public policy support, the costs of wave and tidal technologies are expected to follow the same rapid decrease in price that wind energy has experienced.

4.1.3.4 Ocean Pollution

Environmental contaminants in the form of waste materials, sewage, and toxins are present in, and continue to be released into, the ocean off the PACNW. Polluted runoff, or non-point source pollution, is considered the major cause of impairment of ocean waters. Stormwater runoff from coastal urban areas and beaches carries waste such as plastics and Styrofoam into coastal waters. Sewer outfalls also are a source of ocean pollution in the PACNW. Sewage can be treated to eliminate potentially harmful releases of contaminants; however, releases of untreated sewage occur due to infrastructure malfunctions, resulting in releases of bacteria usually associated with feces, such as *Escerichia coli* and *enterococci*. Bacteria levels are used routinely to determine the quality of water at recreational beaches, and as indicators of the possible presence of other harmful microorganisms.

As recent as 2006, toxic chemicals have been released into sewer systems in the PACNW; a fine of $180,000 was levied against a Redmond fish-food and aquaculture company for dumping toxic chemicals into the sewer drain, failing to separate potentially explosive chemicals and hazardous materials (Seattle

2008a). While such dumping has long been forbidden by law, the practice has left ocean outflow sites contaminated. Superfund cleanup sites have been identified in the Puget Sound and dredge spoils are slated to be dumped within the bay (Seattle 2007). These sites of accumulation are being rectified by Superfund cleanups in the Sound.

Sewage treatment facilities generally do not treat or remove persistent organic pollutants. Plastic and Styrofoam waste in the ocean chemically attracts hydrocarbon pollutants such as Polychlorinated Biphenyls (PCBs) and Dichloro-Diphenyl-Trichloroethane (DDT), which accumulate up to 1 million times more in plastic than in ocean water. Fish, other marine animals, and birds consume these wastes containing elevated levels of toxins. DDT mimics estrogen in its effects on some animals, possibly causing the development of female characteristics in male hornyhead turbots and English sole, according to a study by the Southern California Coastal Water Research Project.

Regulatory activities have made progress in reducing both non-point source pollution such as runoff, and point source pollution such as that which may emanate from sewer outfall sites. In 1998, Washington and Oregon received conditional Federal approval of its Coastal Nonpoint Source Pollution Control Program from the U.S. Environmental Protection Agency and the National Oceanic and Atmospheric Administration (the agencies that administer the Clean Water Act and Coastal Zone Management Act, respectively). The program includes the coordinated participation of the Coastal Commission, the State Water Resources Control Board, and the Regional Water Quality Control Boards. The current plan covers the years 2003 to 2008.

Pollution from vessels is a source of ocean contamination. Sewage, sludge, blackwater, graywater, bilge water, plastics and other trash components and waste materials are routinely discharged from vessels into coastal and ocean waters in the PACNW. Most recently, an international shipping company was fined $7.25 million for dumping oil sludge at sea, the largest penalty for dumping ever assessed in the Pacific Northwest (Seattle 2008b).

Increases in impervious surfaces increase the amount of chemicals, oils and other residues which end up in the human food chain. Impervious surfaces are mainly constructed surfaces - rooftops, sidewalks, roads, and parking lots - covered by impenetrable materials such as asphalt, concrete, brick, and stone. These materials seal surfaces, repel water and prevent precipitation and meltwater from infiltrating soils. Soils compacted by urban development are also highly impervious. They can also lead to impaired freshwater quality that is cleaned up at considerable taxpayer expense. Many of these chemicals attach themselves to the stream bottom (sediment) and to the fatty tissue of fish and other animals. In the case of persistent organic pollutants, or POPs, the chemicals build up with each successive eater in the food chain. In most cases, we are seeing contamination which lasts for over 30 years even if the chemical has stopped being used. Flame retardants (polybrominated diphenyl ethers) and PCBs, are examples.

Increases in impervious surfaces also increase the delivery of bacteria and pathogens - associated with the fecal waste of wild, domestic and human animals. Some of these can cause illness in humans from swimming or contact with contaminated waters or beaches or from eating contaminated shellfish. Potential illnesses and afflictions that can result include general intestinal distress, giardia, hepatitis and a range of other ailments.

4.1.3.5 Coastal Development

“Smart Growth" strategies in both BC and Washington encompass these elements:

- Growth Management
- Land Use Planning and Urban Design
- Economic Incentives
- Demand Management Practices (creating the demand for innovative products and services)

- Watershed and Integrated Natural Resource Management

Washington State adopted the Growth Management Act (GMA) in 1990-1991 (Revised Code of Washington, Title 36, Chapter 36.70A), requiring a comprehensive approach to managing growth. The Act requires:

- Adoption of local and regional plans to manage growth
- Designation and protection of environmentally critical areas
- Consistency between jurisdictions' local plans, and consistency between plans and development regulations, so that adopted policies guide our day-to-day actions

More recent amendments have integrated GMA with other environmental regulations such as the State Environmental Policy Act, to streamline the processes without compromising the protections. Please see the Urbanization and Forest Change indicator for more detail regarding the GMA.

4.1.3.6 Regional Growth Management (Provincial Legislation)

Coastal development intensifies use of coastal resources, resulting in potential impacts on water quality, wildlife and fish habitat, air quality, and intensity of land and ocean use. Coastal development is therefore closely regulated in Washington, Oregon, and California. (See Section 6.1.1 for a detailed discussion of regulation of activities in the coastal zone.) New development in the coastal zone may require a permit from the California Coastal Commission, Washington State's coastal zone management program, Oregon's Coastal Management Plan, or a local government to which permitting authority has been delegated by the Coastal Management Agency. A Coastal Development Permit is generally required for any project in the Coastal Zone that includes:

- the placement of any solid material or structure;
- a change in land use density or intensity (including any land division);
- change in the intensity of water use or access to water; or
- removal of major vegetation.

Some types of development are exempt from coastal permitting requirements, including in many cases, repairs and improvements to single-family homes, certain "temporary events," and, under specified conditions, replacement of structures destroyed by natural disaster.

Local Coastal Programs (LCPs) identify the locations, types, densities and other ground rules for future development in the coastal-zone portions of all cities and counties along the coast. Each LCP includes a land-use plan and its implementing measures (e.g., zoning ordinances). Prepared by local government and approved by the Coastal Commission, these programs govern decisions that affect the conservation and use of coastal resources. While each LCP reflects the unique characteristics of individual local coastal communities, regional and statewide concerns must also be addressed in conformity with the goals and policies of the State Coastal Act.

LCPs are basic planning tools used by local governments to guide development in the coastal zone, in partnership with the Coastal Commission. LCPs contain the ground rules for future development and protection of coastal resources in the coastal cities and counties, including Clallam, Jefferson, San Juan, Skagit, Snohomish, King, Kitsap, Mason, and Grays Harbor Counties. The LCPs specify appropriate location, type, and scale of new or changed uses of land and water. Each LCP includes a land use plan and measures to implement the plan (such as zoning ordinances). Following adoption by a city council or county board of supervisors, an LCP is submitted to the Coastal Commission for review for consistency with Coastal Act requirements.

Coastal development in the PACNW is both intensive and extensive, and the coast adjacent to the NWTRC is densely populated. This development has impacted and continues to impact coastal resources in ROI including through: point source and non-point source pollution; intensive boating and other recreational use; intensive commercial and recreational sport fishing; intensive ship traffic using major port facilities at Seattle, Tacoma, and Everett. Regulation of these activities through the Coastal Development programs discussed above serves primarily to limit new development; however, the coastal zone is already fully developed in many areas, with associated ongoing impacts.

4.1.3.7 Scientific Research

There are currently 30 scientific research permits and General Authorizations for research issued by the National Marine Fisheries Service (NMFS) for cetacean work in the wild in the North Pacific. The most invasive research involves tagging or biopsy while the remainder focuses on vessel and aerial surveys and close approach for photo-identification. Species covered by these permits and authorizations include small odontocetes, sperm whales and large mysticetes. One permit issued to the Office of Protected Resources of NMFS allows for responses to strandings and entanglements of listed marine mammals. NMFS has also issued General Authorizations for commercial photography of non-listed marine mammals, provided that the activity does not rise to Level A Harassment of the animals. These authorizations are usually issued for no more than 1 or 2 years, depending on the project.

The impacts of this type of research are largely unmeasured. However, given the analysis and scrutiny given to permit applications, it is assumed that any adverse effects are largely transitory (e.g., inadvertent harassment, biopsy effects, etc.). Data to assess population level effects from research are not currently available, and even if data were available it is uncertain that research effects could be separately identified from other adverse effects on cetacean populations in PACNW waters.

4.1.3.8 Commercial and General Aviation

The PACNW is served by several large commercial airports. Seattle-Tacoma International Airport (Sea-Tac), Bellingham International (Whatcom County), and Jefferson County International (Jefferson County) are all situated on or nearby the coastline, while Spokane International Airport is situated in Spokane County, approximately 20 miles west of the Idaho border.

Smaller general aviation airports are located throughout the PACNW and increase low altitude traffic. Aircraft operating under visual flight rules (VFR) can fly south along the coast largely unrestrained between Washington and other states and east to inland destinations except by safety requirements and mandated traffic flow requirements. Aircraft operating under Instrument Flight Rules (IFR) clearances, authorized by the FAA, normally fly on the airway route structures. In the PACNW these routes include both high- and low- altitude routes between neighboring airports. Three Control Area Extensions (CAE), that run from the PACNW through the offshore warning areas, facilitate access to the airways to Hawaii and other trans-Pacific locations. All three CAEs follow routes that remain clear of W-237, W-570, and W-93. When any warning areas are active, aircraft on IFR clearances are precluded from entering the areas by the FAA. However, since W-237, W-570, and W-93 are located entirely over international waters, nonparticipating aircraft operating under VFR are not prohibited from entering the area. Examples of aircraft flights of this nature include light aircraft, fish spotters, and whale watchers.

4.1.3.9 Air Quality Factors

In the EPA emission inventories by category for 2004 and projected for 2020, the PSGB includes emissions from aircraft, ships, and commercial boats. Emissions estimates are based on emissions from onshore or nearshore activities. These emissions would account for a small percentage of the overall air emissions budget and in air quality planning because they are assumed to have a negligible effect on the ambient air quality, and because reductions in emissions from these sources would not generate a great improvement in the ambient air quality. The Community Multi-scale Air Quality (CMAQ) modeling system was selected to study ozone and aerosol concentrations and the visibility impacts of the aerosol concentrations in the PACNW. This was undertaken as part of the Northwest Regional Modeling Center (NWRMC) CMAQ demonstration project to demonstrate the applicability of CMAQ to the PACNW and to establish a virtual modeling center accessible to all Northwest air quality stakeholders. The domain encompasses the States of Washington, Oregon, and Idaho, and a large portion of southwestern Canada. Two emission inventories (EI) were developed for this project for the July 1-15, 1996 period. Anthropogenic emissions for the first EI were based upon the National Emission Trend 1996 (NET 1996) database, and biogenic emissions were obtained from the BEIS2 biogenic emissions model. The NET96 data were at a 36 kilometers (km) resolution and required interpolation to the 12 km PACNW domain. Anthropogenic emissions for the second EI were developed as a "ground up" approach by the NWRMC, and biogenic emissions were obtained from the GLOBEIS biogenic emissions model (Washington State 2008).

4.1.4 Habitats of Migratory Marine Animals

Migratory or wide-ranging marine mammals and sea turtles that may be present in the NWTRC may be affected by natural events and anthropogenic activities that occur in areas far removed from the PACNW, on breeding grounds, migration routes, wintering areas, or other habitats within a species' range. Events and activities that affect the habitats of these marine species outside the NWTRC include:

- Disease
- Natural toxins
- Weather and climatic influences
- Navigation errors
- Natural predation
- Fishing
- Hunting (although there are no nesting areas in the NWTRC, sea turtle egg predation is included here)
- Ocean pollution
- Habitat modification or destruction
- Ship traffic

These stressors on marine habitats and associated effects on marine mammals and sea turtles occurring outside the NWTRC are discussed in detail below.

4.2 CUMULATIVE IMPACT ANALYSIS

4.2.1 Geology and Soils

Cumulative impacts on geology and soils would consist of the combined effects of the Proposed Action and other actions and activities that could alter the local topography or disturb surface soils. Under the Proposed Action, potential impacts to soils may arise from direct disturbance from ordnance explosions, contamination of soils from explosive materials, and vehicle and personnel movement. These activities, would contribute locally and incrementally to increased sediment transport and deposition; however, the cumulative effects on local geology would still be negligible relative to the scale of the natural processes within the area of analysis for geology and soils (refer to Table 4-1). Under the Proposed Action, the Navy would continue to implement its' current protective measures. Therefore, the cumulative effects on geology and soils from implementation of the Proposed Action in combination with past, present, or planned projects and other activities would be minimal.

4.2.2 Air Quality

Activities affecting air quality in the region include, but are not limited to, mobile sources such as automobiles and aircraft, and stationary sources such as power generating stations, manufacturing operations and other industry, and the like. The Puget Sound Georgia Air Basin includes emissions from aircrafts, ships, and commercial boats; these emissions are included in the mobile source category. Traditionally, the emission estimates are based on emissions from onshore or nearshore activities. Emission estimates for these sources are summarized in Table 4-4.

Table 4-4: Emissions Estimates

Emission Source	Emissions, tons/year					
	CO	NOx	ROG	SOx	PM_{10}	$PM_{2.5}$
Within U.S. Territory						
Aircraft Operations	1.35	3.68	0.21	0.19	1.87	1.85
Marine Vessel Operations	3.80	4.50	0.34	0.95	0.16	0.16
Ordnance	0.92	0.06	0.00	0.00	0.09	0.09
Ground Vehicles	1.49	0.12	0.08	0.00	0.00	0.00
Total	**7.56**	**8.36**	**0.63**	**1.13**	**2.12**	**2.10**
Outside U.S. Territory						
Aircraft Operations	4.89	21.62	1.09	1.02	10.25	10.15
Marine Vessel Operations	137.98	85.70	12.43	22.57	4.65	4.60
Total	**142.87**	**107.32**	**13.52**	**23.59**	**14.90**	**14.75**

These emissions would account for a small percentage of the overall air emissions budgets for each of the air basins. They do not include marine vessel emissions for vessels operating outside of U.S. territorial waters. These emissions are generally not included in the State Implementation Plan (SIP) emissions budget and in air quality planning because they are assumed to have a negligible effect on the ambient air quality, and because reductions in emissions from these sources would not generate a great improvement in the ambient air quality. Therefore, the cumulative effects on air quality from implementation of the Proposed Action in combination with past, present, or planned projects and other activities would be minimal.

4.2.3 Hazardous Materials and Wastes

Cumulative impacts associated with hazardous materials and wastes would consist of the combined effects of the Proposed Action and other actions and activities (refer to Section 4.1.2 and 4.1.3) that would use large quantities of hazardous materials, or that would otherwise affect the hazardous materials management system.

The Proposed Action would increase releases to the environment of hazardous materials (expended training materials), but these releases are predicted to have no adverse effects (see Section 3.3). The Navy's existing hazardous materials and hazardous wastes management systems responsible for safely storing and transporting these materials would be able to accommodate the anticipated increases in throughput. No substantial adverse effects have been identified.

The primary impact of hazardous materials use in the marine and terrestrial environment would be an increase in the amounts of munitions, petroleum products or other chemicals that are released. Hazardous materials settling out of the water column would contribute to contamination of ocean bottom sediments. Relevant activities would include releases of hazardous constituents from fishing vessels or other ocean vessels and non-point source pollution from terrestrial sources.

Commercial ocean industries, such as fishing and ocean transport, are dispersed over broad areas of the Pacific Ocean. There is no central point of contaminant discharge, but the intensity of ocean uses, and correspondingly the density of hazardous materials discharges, generally declines with increasing distance from the coast. Discharges of hazardous constituents from non-point source runoff and treatment plant outfalls contribute contaminants to the area, mostly affecting the waters within three nautical miles of the coast. Ocean currents and sediment transport processes disperse the released materials over a large area. Overall, the quality of Pacific Ocean waters and bottom sediments offshore are relatively high, indicating that current releases of hazardous materials are generally not causing substantial adverse effects. Releases of hazardous materials under the Proposed Action, along with those of other reasonably foreseeable future projects and activities, would not substantially alter the quantities of these materials being discharged, and thus would not substantially affect resources in the Study Area.

Generally, hazardous materials used on land consist primarily of fuels and other petroleum products; paint, adhesives, glues, other coatings; and other materials used in construction. Use of these materials is closely regulated by local, state, and federal agencies, and off-site releases of substantial quantities of these items is rare. The overall risk of a substantial release of such materials from the Proposed Action or other projects is low.

Hazardous wastes generated aboard vessels engaged in training activities under the Proposed Action would offload those wastes to Navy shore facilities, where they would become part of the overall hazardous waste stream managed by the appropriate Navy facility. Increased levels of training would result in increased throughput of hazardous wastes, but likely would not require additional storage, transport, or disposal facilities ashore for these materials. The Navy's hazardous waste management system and procedures are adequate to accommodate an increase in hazardous waste volumes. Other hazardous waste generators in the region, along with the Navy, would require the services of hazardous waste transporters and treatment, storage, and disposal facilities. While the costs for hazardous waste transport, treatment, storage, and disposal could increase substantially in response to increased cumulative demand, the hazardous waste management industry in the region has sufficient physical capacity to respond to this increased demand.

Therefore, the cumulative effects of hazardous materials uses and hazardous waste generation from the Proposed Action and other reasonably foreseeable future projects and activities on environmental resources and on the regional hazardous wastes treatment, storage, and disposal infrastructure would be minimal.

4.2.4 Water Resources

Cumulative impacts on water resources would consist of the effects of the Proposed Action when added to other projects and actions that affect marine, surface or ground water hydrology; that release potential water pollutants or otherwise result in long-term degradation of marine, surface, or ground water quality; that deposit sediment or debris, alter bathymetry, or disturb ocean bottom sediments; and that have substantial effects on public uses of State or federal waters.

The Proposed Action is expected to have no substantial effects on marine, surface, or ground water quality (see Section 3.4). The Proposed Action would affect marine geology and sediments by creating craters in bottom sediments and depositing training debris on the ocean bottom. The Proposed Action is expected to increase the level of marine sediment disturbance but not to a substantial degree (see Section 3.4). It also is expected to disturb small areas of benthic habitat in combination with underwater detonations required for training. No substantial increases in erosion or off-site sediment transport, or changes in topography are predicted. The Proposed Action would expend training materials (see Table 3.4-32) some of which would not be recovered. However, overall, no substantial adverse effects on marine sediments were identified for the Proposed Action.

The Proposed Action would be consistent with the National Ambient Water Quality Criteria. Releases of potential water contaminants from proposed training activities would be minimal, and no long-term degradation of water quality would occur. Cumulative impacts on marine, surface, or ground water quality and marine sediments would consist of the aggregate effects of the Proposed Action and other military and civilian projects and activities within the Study Area. Navy training would result in materials expended in the water that are considered pollutants; however, compliance with federal and state regulations would limit the release of such pollutants to *de minimis* amounts, which would not result in substantial cumulative effects. In addition, cumulative effects would be negligible relative to the scale of the natural processes operating in the Study Area. Therefore, there would be no cumulative effects on water resources from implementation of the Proposed Action in combination with past, present, or planned projects and other activities within the Study Area.

4.2.5 Acoustic Environment (Airborne)

The Proposed Action activities in the NWTRC Ocean OPAREAs were deemed to have insignificant effects on the marine (airborne) noise environment, due in large part to the absence of human sensitive receptors on these sea ranges. Commercial ship and aircraft traffic, tidal wave generators, and recreational activities all would contribute occasional, short-term noise to small portions of the ocean operating area of the NWTRC. The airborne noises they generate would consist chiefly of short-term intrusive noise events in different locations at different times, similar to those of the Proposed Action. Thus, little or no overlap in location or time of discrete noise events would be expected. Peak and average community noise levels would remain largely unchanged. Additionally, human noise receptors would still be absent. Accordingly, cumulative impacts on the marine noise environment would be less than significant.

Cumulative noise sources on Whidbey Island and within the Puget Sound would include range activities, training, and maintenance activities not included in the Proposed Action. Noise from these activities generally would consist of short-term, intrusive noise events at EOD locations and the airfield. Noise levels from flight activities exceeding ambient background sound levels typically occur beneath main approach and departure corridors, beneath local air traffic patterns around an airfield, and in areas immediately adjacent to parking ramps and aircraft staging areas. As aircraft in flight gain altitude, their noise contribution drops to lower levels, often becoming indistinguishable from the background noise.

A portion of the sound attributable to training and testing events in those portions of the NWTRC closest to shore (within three nautical miles), on shore, or over land results from helicopter flights associated with mine countermeasures training, or insertion/extraction. Helicopter noise associated with mine countermeasures training at Crescent Harbor and insertion/extraction training at Crescent Harbor, Seaplane Base, and OLF Coupeville takes place within the existing higher noise contours established by the EA-6B and newer E/A-18G. Likewise, the replacement aircraft for the P-3 (P-8 MMA) will also operate within these noise contours. Helicopter noise in these areas would be either indistinguishable from the background jet noise or masked by the louder jet noise. Mine Countermeasure (MCM) training at Crescent Harbor takes place at a lesser extent offshore from Indian Island (six percent) and at Floral Point (six percent). Airborne noise associated with MCM activities is limited because the detonations take place underwater.

Sound in the nearshore or overland portions of the Range Complex can also result from higher-altitude, fixed-wing aircraft noise associated with electronic combat and air combat maneuvers throughout the inland Military Operating Areas (MOAs), such as Olympic, Darrington, Okanagan, and Roosevelt. Most overland training flights typically occur at altitudes over 10,000 feet above ground level. As mentioned above, high-altitude flight noise is often indistinguishable from the background noise.

An environmental assessment was prepared for the establishment of the Okanagan MOA in 1976 (U.S. Air Force [USAF] 1976). As stated in the environmental assessment, noise impacts were expected to be minimal in that the areas lie over sparsely populated mountainous forest terrain with minimum altitudes over 5,000 feet above any populated centers (USAF 1976). The frequency of use is spread over a large enough area that recurring passage over the same place is only by chance. Recreation centers were not likely to be affected. Average noise levels could not be computed, since aircraft fly random flight paths within the areas. All aircraft operate at subsonic speed while at low level altitudes and while over land. Supersonic flights and their associated sonic booms are conducted only in the Offshore Area under conditions approved by the Navy. Other MOAs overlie similarly sparsely populated areas, and aircraft passage over the same place is only by chance. Commercial flight paths occur throughout these areas as well but only increase effects with background overhead noise from high altitude fly over. Other recreational aircraft would be found in the areas but only a minor effect would be had by these flights; it would not be likely that recreational aircraft would continue occurring over the same areas because recreational aircraft operate without strict flight paths.

Airborne sound from Navy training in the nearshore or on-land portions of the complex can stem from the occasional land demolition at the Seaplane Base or Naval Base Kitsap (NBK) Bangor detonation training range. Land demolition training occurs primarily at Seaplane Base (94 percent), and has been occurring at Seaplane Base for approximately 15 years. UAS flights from Admiralty Bay would also contribute to noise in this area to a minor extent as well.

While persons on recreational or fishing vessels in the Puget Sound, Straight of Juan de Fuca, Crescent Harbor, Admiralty Bay, and Hood Canal might be exposed to sound generated by military activities, sound levels would be low and would cause mild interference with non-participant vessels in the area of training.

Sensitive receptors are those noise-sensitive areas, including developed and undeveloped areas for land uses such as residences, businesses, schools, churches, libraries, hospitals, and parks. Military personnel are not considered to be sensitive receptors of airborne noise for purposes of environmental impact analysis. The nearest shore-based sensitive receptors would be located in residences and community facilities outside of the Seaplane Base and near Crescent Harbor. Sensitive receptors at these locations may experience occasional noise associated with land demolitions and helicopter flight training in this area. Local noise associated with small airfields in the Puget Sound area as well as commercial aircraft generated from local international airports would also contribute to the overall noise of the area. Recreational watercraft and commercial shipping will also contribute to the noise found in the Puget Sound. Levels will be higher during peak seasons and weekend operation of these vessels.

In the area of airborne sound, the primary impacts of proposed Navy activities are geographically isolated from population centers and otherwise will not affect natural resources. Thus, noise impacts from these proposed activities would be minimal. Therefore, there would be no cumulative effects on the acoustic environment as a result of implementation of the Proposed Action in combination with past, present, or planned projects and other activities within the Study Area.

4.2.6 Marine Plants and Invertebrates

Potential cumulative impacts on marine plants and invertebrates in the NWTRC include releases of chemicals into the ocean, introduction of debris into the water column and onto the seafloor, and mortality and injury of marine organisms near the detonation or impact point of ordnance or explosives.

Materials expended during training include sonobuoys; parachutes and nylon cord; towed, stationary, and remote-controlled targets; inert ordnance; unexploded ordnance, and fragments from exploded ordnance, including missiles, bombs, and shells. Materials include a variety of plastics, metals, and batteries. Unless otherwise noted in the discussion or the table, targets are not recovered. Most of these materials are inert and dense, and will settle to the bottom where they will eventually be covered with sediment or encrusted by physical or biological processes.

Detonated ordnance used in mine countermeasure training produce negligible amounts of solid materials because the bulk of the explosive is consumed in the explosion. Other material effects from commercial and recreational fishing, point-source pollution accumulation, and other non-point source pollution sources would contribute to a much greater extent to the material wastes found in the Puget Sound and northwest areas. The presence of persistent organic compounds such as DDT and PCBs from non-Navy sources are of particular concern. In light of these concerns, Navy activities would have small or negligible potential impacts.

The Proposed Action was evaluated for long-term effects on marine communities that would result from explosions, based on their force, location, and proximity to the bottom. Short-term effects, including increases in local turbidity and the creation of shallow depressions in bottom sediments, were not considered because they disappear relatively quickly under the influence of ocean and tidal currents and the natural sediment transport processes that operate continuously in the ocean and the sound.

Based on the analysis presented in Section 3.6, there would be no long-term changes to species abundance or diversity, no loss or degradation of sensitive habitats, and no effects to threatened and endangered species. None of the potential impacts would affect the sustainability of resources, the regional ecosystem, or the human community. Therefore, there would be no cumulative effects on marine plants and invertebrates as a result of implementation of the Proposed Action in combination with past, present, or planned projects and other activities within the Study Area.

4.2.7 Fish

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

The NWRTC Study Area includes critical habitat areas designated for the Puget Sound chinook salmon, Hood Canal summer-run chum salmon, and Coastal-Puget Sound bull trout. Threatened species potentially affected include the Puget Sound chinook salmon ESU, Hood Canal summer-run chum salmon ESU, Coastal-Puget Sound bull trout DPS, and Puget Sound steelhead trout DPS.

Due to the wide geographic separation of most of the activities, Navy activities would have small or negligible potential impact, and their potential impacts are not additive or synergistic. Relatively small number of fish would be killed by shock waves from mines, inert bombs, and intact missiles and targets hitting the water surface. These and other types of activities common to many exercises or tests have less-than-significant effects on fish; aircraft, missile, and target overflights; muzzle blasts from 5-inch guns; releases of munitions constituents; falling debris and small arms rounds; entanglement in military-related debris; and chaff and flares. As described in Section 3.7, there would be no long-term changes in species abundance or diversity, and no loss or degradation of sensitive habitats. Explosive ordnance may result in injury or mortality to individual fish but would not result in impacts to fish populations.

Underwater explosives may result in disturbance, injury, or mortality to ESA-listed salmonid species. However, under the Proposed Action, the total number of underwater detonations would decrease from 60 events to 4 events annually. While a decrease in underwater detonations under the Proposed Action would reduce the likelihood of impacts to salmonid species, effects from underwater detonations would have the potential to affect juvenile populations of salmon and bull trout based on the size of the charge and the distance from the shoreline that the explosions occur. When adults are in the general vicinity of the training areas, they too could be injured or killed as a result.

In June 2008, NMFS issued a Biological Opinion for Navy EOD Operations in three locations in Puget Sound, concluding that EOD is not likely to jeopardize the continued existence of the Puget Sound Chinook salmon, Hood Canal summer-run chum salmon, or Puget Sound steelhead trout. NMFS further concluded that EOD activities are not likely to adversely modify critical habitat of Puget Sound Chinook salmon or Hood Canal summer-run chum salmon (NMFS 2008).

Based on the analysis provided in Section 3.8, impacts to fish from explosions would be possible, but have a low potential for occurrence. While serious injury and/or mortality to individual fish would be expected if they were present in the immediate vicinity of underwater detonations and high explosive ordnance use, explosions would not result in impacts to fish populations based on the low number of fish that would be affected. Disturbances to water column and benthic habitats from explosions would be short-term and localized. The Navy conducts a limited number of training activities over a large area (112,241 nm^2 [430,000 km^2]). Habitat disturbance and fish injury and mortality from explosions are reduced by Navy mitigation measures, as discussed in Section 3.7.1.6. Therefore, no long-term changes in species abundance or diversity, no loss or degradation of sensitive habitats, and only potential effects to threatened and endangered species may occur. In addition, based on the analysis provided in Section 3.8, none of the potential impacts would affect EFH, sustainability of resources, the regional ecosystem, or the human community.

Navy activities coupled with other consistent underwater noise sources from commercial and recreational noises would not create a considerable impact (refer to Section 3.8). Therefore, there would be no cumulative effects related to fish as a result of implementation of the Proposed Action in combination with past, present, or planned projects in the Study Area.

4.2.8 Sea Turtles

The only species of sea turtle expected to occur regularly in the NWTRC Study Area is the leatherback turtle (refer to Section 3.8). The Study Area is an important foraging habitat for leatherbacks that nest in Indonesia, although the turtles appear to cluster in different locations within the region during different years (DoN 2007).

Leatherback turtles are globally distributed. Leatherback turtle nesting grounds are located around the world, with the largest remaining nesting assemblages found on the coasts of northern South America and West Africa. The U.S. Caribbean, primarily Puerto Rico and the U.S. Virgin Islands, and southeast Florida support minor nesting colonies, but represent the most significant nesting activity within the United States. Adult leatherbacks are capable of tolerating a wide range of water temperatures, and have been sighted along the entire continental coast of the United States as far north as the Gulf of Maine and south to Puerto Rico, the U.S. Virgin Islands, and into the Gulf of Mexico. The Pacific Ocean leatherback population is generally smaller in size than that in the Atlantic Ocean. Leatherback turtles are endangered throughout their range (NOAA 2007).

Incidental ‘take’ in fishing operations, or bycatch, is one of the most serious threats to sea turtle populations. In the Pacific, NMFS requires measures (e.g., gear modifications, changes to fishing practices, and time/area closures) to reduce sea turtle bycatch in the Hawaii- and California-based pelagic longline fisheries and the California/Oregon drift gillnet fishery.

Because of the high potential for interactions between leatherback turtles and drift gillnet fisheries off the U.S. west coast during periods of warmer water, the NMFS has designated the eastern north Pacific Ocean area as a “Pacific Leatherback Conservation Zone.” (See Figure 3.8-2 in Section 3.8.) Within this zone from August 15 through November 15 every year, fishing with drift gillnets with a mesh size equal to or greater than 14 inches (36 centimeters) is prohibited. The conservation zone is roughly located between Point Conception, California (34 27’N) and northern Oregon (45 N), and is described fully in 50 CFR 660.713(c). The Pacific Leatherback Conservation Zone protects this species from gillnets at the time of the year when they are known to reside off the U.S. west coast.

Sea turtles can be affected by marine debris when it is ingested or they become entangled in debris (e.g., tar balls, plastic bags, plastic pellets, balloons, and ghost fishing gear). Marine pollution from coastal runoff, marina and dock construction, dredging, aquaculture, oil and gas exploration and extraction, increased underwater noise, and boat traffic can also degrade marine habitats used by sea turtles. In addition, sea turtles swimming or feeding at or just beneath the surface of the water are vulnerable to boat and vessel strikes, which can result in serious propeller injuries and death. The nature is which some sea turtle species function within the marine ecosystem is still poorly understood. Global climate change could potentially have an extensive impact on all aspects of a turtle's life cycle, as well as impact the abundance and distribution of prey items. Loss or degradation of nesting habitat resulting from erosion control through beach nourishment and armoring, beachfront development, artificial lighting, and non-native vegetation is a serious threat affecting nesting females and hatchlings (NOAA 2007).

Temporary disturbances associated with NWTRC activities could result in an incremental contribution to cumulative impacts on leatherback turtles. However, protective measures identified in Section 3.8.1.3 would minimize any potential adverse effects on leatherback turtles. Implementation of the Proposed Action is not likely to affect the species’ or stock’s annual rates of recruitment or survival. Therefore, the incremental impacts of the Proposed Action would not present a significant contribution to the effects on leatherback turtles when added to effects from other past, present, and reasonably foreseeable future actions.

4.2.9 Marine Mammals

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

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

<u>Natural Stressors</u>

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

<u>Human-Influenced Stressors</u>

- Ship strikes
- Pollution and ingestion
- Noise

4.2.9.1 Natural Stressors

Significant natural causes of mortality, die-offs, and stranding discussed below include disease and parasitism; marine neurotoxins from algae; navigation errors that lead to inadvertent stranding; and climatic influences that impact the distribution and abundance of potential food resources (i.e., starvation) (Table 4-5). Stranding also is caused by predation by other species such as sharks (Cockcroft et al. 1989; Heithaus, 2001), killer whales (Constantine et al. 1998; Guinet et al. 2000; Pitman et al. 2001), and some species of pinnipeds (Hiruki et al. 1999; Robinson et al. 1999).

Disease

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

Marine Neurotoxins

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

Table 4-5: Marine Mammal Unusual Mortality Events in the Pacific Attributed to or Suspected From Natural Causes 1978-2005

Year	Species	Location	Cause
1978	Hawaiian monk seals	NW Hawaiian Islands	Ciguatoxin and maitotoxin
1983	Multiple pinniped species	West coast of U.S., Galapagos	El Nino
1984	California sea lions	California	Leptospirosis
1987	Sea otters	Alaska	Saxitoxin
1995	California sea lions	California	Leptospirosis
1997-98	California sea lions	California	El Nino
1998	California sea lions	California	Domoic acid
1998	Hooker’s sea lions	New Zealand	Unknown, bacteria likely
2000	California sea lions	California	Leptospirosis
2000	California sea lions	California	Domoic acid
2000	Harbor seals	California	Unknown; Viral pneumonia suspected
2002	Multispecies (common dolphins, California sea lions, sea otters)	California	Domoic acid
2002	Hooker’s sea lions	New Zealand	Pneumonia
2003	Multispecies (common dolphins, California sea lions, sea otters)	California	Domoic acid
2003	Beluga whales	Alaska	Ecological factors
2003	Sea otters	California	Ecological factors
2004	California sea lions	Canada, U.S. West Coast	Leptospirosis
2005	California sea lions; Northern fur seals	California	Domoic acid

Note: Data from Gulland and Hall (2007); citations for each event contained in Gulland and Hall (2007)

Weather Events and Climate Influences

Severe storms, hurricanes, typhoons, and prolonged temperature extremes may lead to local marine mammal strandings (Geraci et al. 1999; Walsh et al. 2001). Storms in 1982-1983 along the California coast led to deaths of 2,000 northern elephant seal pups (Le Boeuf and Reiter 1991). Seasonal oceanographic conditions in terms of weather, frontal systems, and local currents may also play a role in stranding (Walker et al. 2005).

The effect of large-scale climatic changes to the world’s oceans and how these changes impact marine mammals and influence strandings are difficult to quantify, given the broad spatial and temporal scales involved, and the cryptic movement patterns of marine mammals (Moore 2005; Learmonth et al. 2006).

The most immediate, although indirect, effect is decreased prey availability during unusual conditions. This, in turn, results in increased search effort required by marine mammals (Crocker et al. 2006), potential starvation if not successful, and corresponding stranding due directly to starvation or succumbing to disease or predation while in a weakened, stressed state (Selzer and Payne 1988; Geraci et al. 1999; Moore, 2005; Learmonth et al. 2006; Weise et al. 2006).

Navigational Error

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

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

Social Cohesion

Many pelagic species such as sperm whales, pilot whales, melon-head whales, false killer whales, and some dolphins occur in 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 2007a).

4.2.9.2 Anthropogenic Stressors

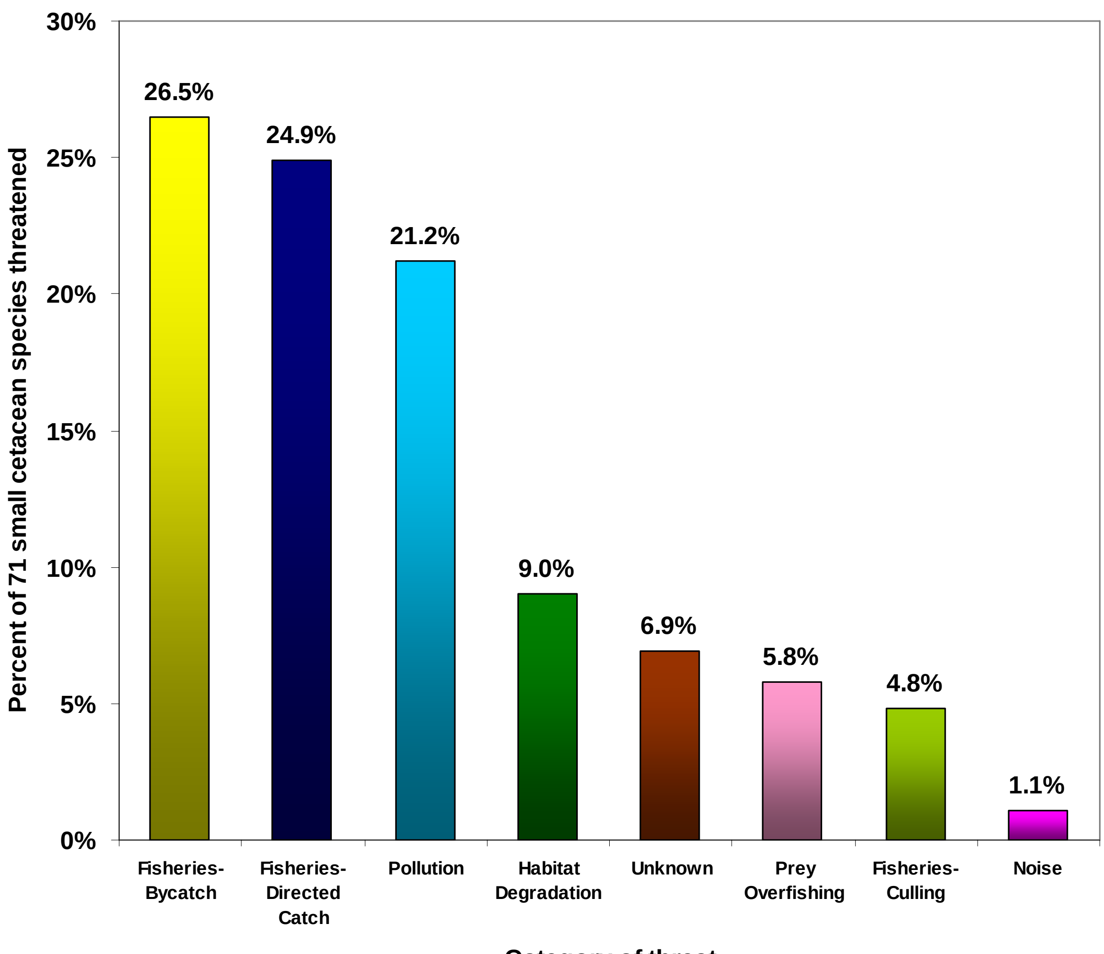
During the past few decades there has been an increase in marine mammal mortalities associated with a variety of human activities (Geraci et al. 1999; NMFS 2007a) (Figure 4-1). These activities include fisheries interactions (bycatch and directed catch), pollution (marine debris, toxic compounds), habitat modification (degradation, prey reduction), ship strikes (Laist et al., 2001), and gunshots.

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 et al. 2002; Culik 2002; Carretta et al., 2004; Geraci and Lounsbury 2005; NMFS, 2007a). 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; Zeeberg 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. Within U.S. fisheries, between 1990 and 1999, the mean annual bycatch of marine mammals was 6,215 animals. Eighty-four percent of cetacean bycatch occurred in gill-net fisheries, with dolphins and porpoises constituting most of the cetacean bycatch (Read et al., 2006). Over the last decade there was a 40 percent decline in marine mammal bycatch, primarily due to effective conservation measures that were implemented during this time period.

Read et al. (2006) extrapolated data for the same period (1990-1999) 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 will be the single greatest threat to many marine mammal populations around the world (Read et al. 2006).



Source: Culik 2002

Figure 4-1: Human Threats to World-wide Small Cetacean Populations

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

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 west coast of the U.S. (California Marine Mammal Stranding Network Database 2006).

Ship Strike

Ship strikes of 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 and the size of the animal (Knowlton and Kraus, 2001; Laist et al., 2001; Vanderlaan and Taggart, 2007).

The growth in commercial ports and associated commercial vessel traffic is a result of the globalization in 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 over 85,000 vessels in 1998 (NRC, 2003; Southall, 2005). 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 that 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 regionally-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.

Ingestion of Plastic Objects and Other Marine Debris and Toxic Pollution Exposure

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

High concentrations of potentially toxic substances within marine mammals along with an increase in new diseases have been documented in recent years. Scientists have begun to consider the possibility of a link between pollutants and marine mammal mortality events. NMFS takes part in a marine mammal 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 with possible adverse health effects in marine mammals (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 (Hickie et al. 2007; Krahn et al. 2007; NMFS, 2007c). Both compounds are long-lasting, reside in marine mammal fat tissues (especially in the blubber), and can have toxic effects such as reproductive impairment and immunosuppression (NMFS, 2007c).

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

U.S. Navy vessel operation between ports and exercise locations has the potential to release 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 bilgewater and deck runoff associated with the vessels would be in accordance with international and U.S. requirements for eliminating or minimizing discharges of oil, garbage, and other substances, and not likely to contribute significant changes to ocean water quality or to affect marine mammals.

Anthropogenic Sound

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

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

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 emissions in the marine environment. Prop-driven vessels also generate noise through cavitation, which accounts much of the noise emitted by a large vessel depending on its travel speed. Military vessels underway or involved in naval activities 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 - 200 dB between 8 Hz and 430 Hz, although Arveson and Vendittis (2000) documented components of higher frequencies (10-30 kHz) as a function of newer merchant ship engines and faster transit speeds. Given the propagation of low-frequency sounds, a large vessel in this sound range can be heard 139-463 kilometers away (Ross 1976 in Polefka 2004). U.S. Navy vessels, however, have incorporated significant underwater ship quieting technology to reduce their acoustic signature (as compared to a similarly-sized vessel) and thus reduce their vulnerability to detection by enemy passive acoustics (Southall, 2005).

Shipboard fathometers are another source of sound emitted from ships. Fathometers have acoustic source levels below 201 dB re 1 μPa at 1 m, generally in the high-frequency range. However, fathometers were not considered a sound source stressor given that at this source level (201 dB re 1 μPa at 1 m) or below, a high-frequency ping would attenuate rapidly over distance.

Naval sonars are designed for three primary functions: submarine hunting, mine hunting, and shipping surveillance. 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 2005).

Both natural and human-induced factors affect the health of marine mammal populations. Temporary disturbance incidents associated with Navy activities on the NWTRC could result in an incremental contribution to cumulative impacts on mammals. Both current protective measures and additional mitigation measures identified in Section 3.9 would be implemented to minimize any potential adverse effects to marine mammals from Navy activities. Impacts associated with the Proposed Action may affect the species through effects on annual rates of recruitment or survival. The Navy is consulting with the NMFS in accordance with the MMPA concerning the potential for impacts to marine mammals resulting from NWTRC activities.

In addition to these activities, Naval Sea Systems Command (NAVSEA) Naval Undersea Warfare Center (NUWC) conducts research, development, test & evaluation (RDT&E) of future navy systems within the Study Area of the NWTRC EIS/OEIS. Based on modeling for NUWC's RDT&E activities (analyzed under a separate EIS/OEIS), estimated acoustic exposures from the use of active acoustic sources are provided in Tables 4-6 and 4-7 for the Dabob Bay Range Complex (DBRC) and the Quinault Underwater Tracking Range (QUTR) sites (see Figure 4-2 and Figure 4-3). Local impacts on marine mammals may be increased with these activities and other past, present, and reasonably foreseeable future actions.

Table 4-6: Estimated Annual MMPA Level B Exposures for Inshore Area - DBRC Site

Species	EL TTS (Level B) Exposures	Risk Function Behavioral Exposures
Killer Whale	0	0
California Sea Lion	0	109
Harbor Seal	1,998	3,320
Total Level B Exposures (by criteria method)	1,998	3,429

Table 4-7: Estimated Annual MMPA Level B Exposures for Offshore Area - QUTR Site

Species	EL TTS (Level B) Exposures	Risk Function Behavioral Exposures
Endangered or Threatened Species		
Blue Whale	0	0
Fin Whale	0	0
Humpback Whale	0	0
Sei Whale	0	0
Sperm Whale	0	0
Killer Whale	0	0
Steller Sea Lion	0	0
Non-ESA Listed Species		
Minke Whale	0	0
Gray Whale	0	0
Dwarf and Pygmy Sperm Whale	0	0
Baird's Beaked Whale	0	0
Mesoplodons	0	0
Risso's Dolphin	0	0
Pacific White Sided Dolphin	0	0
Short Beaked Common Dolphin	0	0
Striped Dolphin	0	0
Northern Right Whale Dolphin	0	0
Dall's Porpoise	0	0
Harbor Porpoise	1	11,282
Northern Fur Seal	0	44
California Sea Lion	0	5

Table 4-7: Estimated Annual MMPA Level B Exposures for Offshore Area - QUTR Site (continued)

Species	EL TTS (Level B) Exposures	Risk Function Behavioral Exposures
Non-ESA Listed Species		
Northern Elephant Seal	0	14
Harbor Seal	23	78
Total Level B Exposures (by criteria method)	24	11,423

4.2.10 Birds

Cumulative impacts on seabirds would consist of the effects of the Proposed Action in conjunction with other projects, actions, and processes that would result in an incremental increase in mortality, disturbance, and habitat modification within the Study Area. Sea bird populations within the NWTRC are affected by direct and indirect perturbations to breeding and foraging locations on the coastal mainland and inshore areas. The single greatest concern is the loss of suitable habitat for nesting and roosting seabirds throughout coastal northwest due to land development and human encroachment. Historically, seabird populations have sustained numerous impacts from pollution and human activities within the PACNORWEST from a variety of sources, including the discharge of hazardous chemicals and sewage. Though the Proposed Action does not directly reduce available seabird habitat within the NWTRC, current seabird populations residing within the Study Area become more susceptible to potential impacts due to the concentrated nature of those populations. By default, open space within military installations in coastal locations has become vital to the persistence of seabird breeding and roosting populations.

Land range operations could affect breeding seabirds if the operational footprint encompassed nesting areas during breeding seasons. Current data on breeding seabird populations that overlap with training operations in or near coastal areas are either unavailable or incomplete, making a comprehensive effects analysis difficult. Though most offshore operations take place in oceanic waters well offshore, are of short duration, and have a small operational footprint, the importance of avoiding sensitive seabird colonies and reducing disturbance should be paramount when accessing new or ongoing training activities.

Training activities concentrated in or near coastal areas or offshore OPAREAs, or taking place at regular intervals, would disturb local seabird roosting colonies. The coastal and offshore OPAREAs within the NWTRC provide suitable seabird habitat adjacent to training areas, allowing potentially affected seabirds adequate alternative locations to avoid interactions with training operations. Continued expansion of commercial and private aircraft and ocean-going vessels through the Range Complex, together with increased NWTRC training activities, elevates the potential for direct and indirect impacts on isolated seabird populations. The control of non-native plants and animals within coastal areas and on islands must continue to be addressed by land owners to ensure further degradation of seabird populations does not occur. Large-scale effects on seabird populations such as global warming, reduced fish populations, and development in other regions or countries are not well defined for individual species but have been attributed to the overall decline of seabirds.

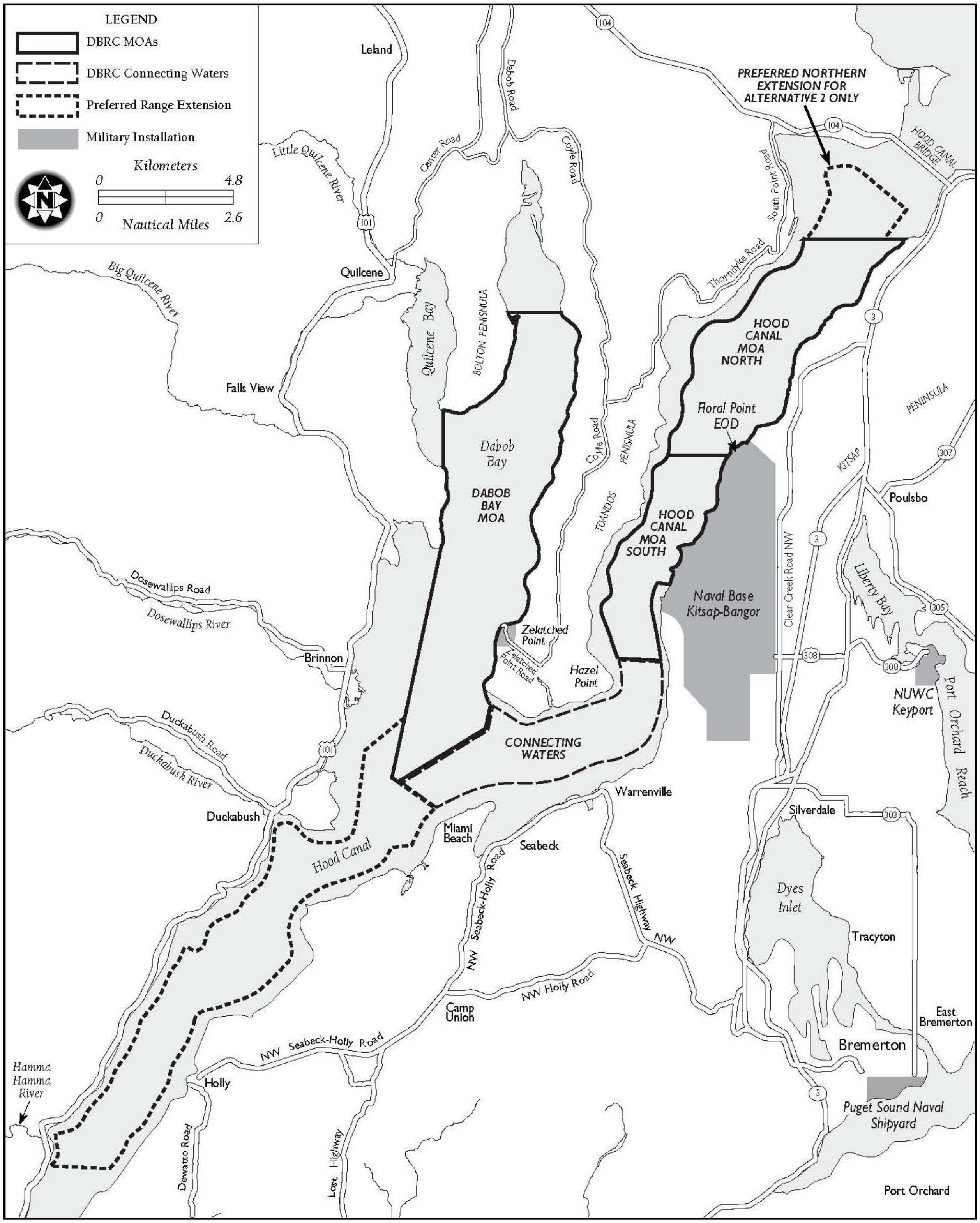


Figure 4-2: Dabob Bay Range Complex Preferred Site Extension Alternative

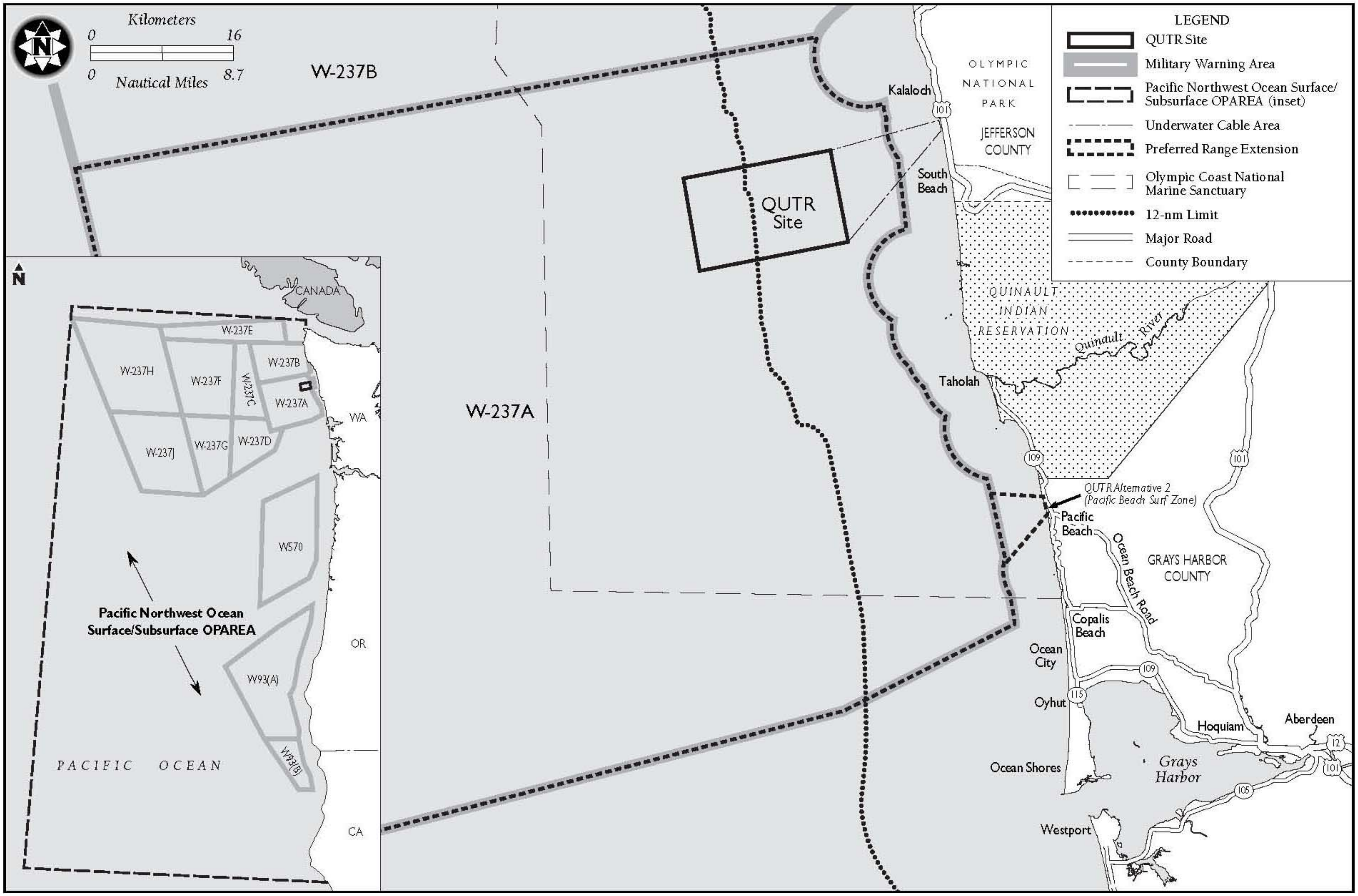


Figure 4-3: Quinault Underwater Tracking Range Preferred Range Extension Alternative

Listed sea bird species in the NWTRC include the Short-tailed Albatross, the Marbeled Murrelet, the California Brown Pelican, and the Western Snowy Plover. In accordance with ESA, under the Proposed Action, vessel movements, aircraft overflights, ordnance use, underwater explosions and detonations, and entanglement may affect but are not likely to adversely affect the listed sea bird species population, overall foraging success, or breeding opportunities. The cumulative impact of the Proposed Action and the identified projects activities in Section 4.1.2 and 4.1.3 could impact individual seabirds, their overall foraging success, and breeding opportunity, but these effects are not likely to adversely affect any seabird population. Therefore, there would be no cumulative effects related to seabirds as a result of implementation of the Proposed Action in conjunction with past, present, or planned projects in the Study Area.

4.2.11 Terrestrial Biological Resources

The analysis for cumulative impacts to terrestrial biology focuses on fire, invasive species, erosion, or habitat modification from past, present and future actions. These actions are evaluated based on the area the individual action encompasses and the value and type of habitat known to occur within the specific footprint. Damage to a resource is considered significant if the area of impact is substantial compared to habitat availability or scarcity, and whether the impacted resource has a special sensitivity status as recognized by resource agencies. An effect is also considered significant if the intensity, duration, or frequency of the action is such that the area cannot recolonize to former species abundance levels; the loss of habitat or habitat value (based on organism density or relative abundance) is considered permanent compared to background variation in these conditions.

Several activities contribute cumulatively to habitat degradation, including disturbance to soils and vegetation, spread of invasive non-native species, erosion and sedimentation, and impacts on native plant species. However, some potential effects of invasive species are difficult to foresee (such as leading to a change in fire frequency or intensity). It is clear, however, that the potential for damage associated with introduction or spread of invasive plant species is high and increases over time with repeated training missions, especially exercises that cover a very large area. This is due to the difficulty in effectively monitoring for invasive establishment and achieving timely control. The Navy is addressing these effects in several important ways including implementation of the NASWI INRMP and the NBC-Bangor INRMP and continued development and implementation of measures to prevent the establishment of invasive plant species by minimizing the potential for introductions of seed or other plant parts (propagules) of exotic species and finding and eliminating incipient populations before they are able to spread (DoN 1996).

Navy projects within the Puget Sound other than the Proposed Action and other activities, such as those identified in Section 4.1.2 and 4.1.3 also could impact terrestrial biological resources. Any such project in the NWTRC would be required to be in compliance with the established INRMP and U.S. Fish and Wildlife Service Biological Opinions issued after Endangered Species Act Section 7 consultation addressing direct, indirect, and cumulative impacts. As identified in Section 3.11, there are numerous potential impacts of the Proposed Action on terrestrial biology on Whidbey and Indian Islands. These impacts have the potential for significant cumulative impact on such resources. Mitigation measures identified in this EIS/OEIS, considered together with any additional mitigation or conservation measures that might be appropriate after Section 7 consultation, however, will substantially mitigate direct, indirect, and cumulative effects of the Proposed Action.

4.2.12 Cultural Resources

Cumulative impacts on cultural resources would consist of the effects of the Proposed Action in combination with other projects, actions, and processes that would result in potential impacts on cultural, archaeological, and historic sites.

This EIS/OEIS determined that the Proposed Action would have little or no potential to impact underwater cultural resources within the Study Area, primarily because most of the Proposed Action's activities were on or above the surface and cultural resources, if any, are on the ocean bottom. Project activities would not generally disturb areas where cultural resources are known or expected to be present. For the same reason, most other ongoing and anticipated ocean activities such as commercial ship traffic, fishing, oil and gas development, or scientific research, would not substantially affect underwater cultural resources.

This EIS/OEIS examined the potential for impacts on cultural, archaeological, and historic sites in the NWTRC OPAREA. Due to the large number of known and estimated cultural sites on Whidbey Island, the use of the island and underwater ranges for training and other Naval Special Warfare activities, the Proposed Action could increase the potential for significant impacts. However, implementation of protective measures as described in Section 3.12.2.1.6 should reduce impacts to a level less than significant. Any activities with the potential for significant impacts on cultural resources will require Section 106 consultation, and would be mitigated as required.

Any proposed construction projects and activity on Whidbey Island as well as on the Olympic Peninsula and Indian Island areas with the potential to disturb cultural resources would be required to evaluate their potential effects and, if necessary, implement mitigation measures similar to those described for the Proposed Action. Where avoidance was practiced, no cumulative effect would result because no contact with the resource would occur. Where data recovery was practiced, the cumulative effect would be that more cultural sites underwent data recovery and removal than would occur under the Proposed Action alone.

4.2.13 Traffic (Airspace)

Cumulative impacts on airspace traffic would consist of the effects of the Proposed Action in combination with other projects, actions, and processes that would result in increased air traffic volumes or conflicts in the Study Area. The region that includes the NWTRC does not propose any expansion of military Special Use Airspace, and would not produce any significant regional cumulative traffic impacts. While hazardous activities in W-237, W-570, and W-93 are in progress, vessel traffic, forewarned through publication of the related Notice to Mariners (NOTMAR) and Notice to Airmen (NOTAM), would avoid the affected area. While hazardous activities occur within the inland Military Operating Areas (MOA), military flight plans are coordinated with Seattle ARTCC. Although the resultant detour might be inconvenient, it would not preclude the affected vessel from arriving at his destination. Coordination with the Federal Aviation Administration on matters affecting airspace significantly reduces or eliminates the possibility of indirect adverse impacts and associated cumulative impacts on civil aviation and airspace use.

4.2.14 Socioeconomics

Cumulative impacts on socioeconomics would consist of the effects of the Proposed Action in combination with other projects, actions, and processes that would result in any significant effect to regional employment, income, housing, or infrastructure. Implementation of the Proposed Action would not produce any significant regional employment, income, housing, or infrastructure impacts. Effects on commercial and recreational fishermen, divers, and boaters would be short-term in nature and produce some temporary access limitations. Some offshore activities, especially if coincident with peak fishing locations and periods, could cause temporary displacement and potential economic loss to individual fishermen. However, most offshore activities are of short duration and have a small operational footprint. Effects on fishermen are mitigated by a series of Navy initiatives, including public notification of scheduled activities, near-real time schedule updates, prompt notification of schedule changes, and adjustment of hazardous operations areas. In selected instances where safety requires exclusive use of a specific area, fishermen may be asked to relocate to a safer nearby area for the duration of the exercise. These measures should not significantly impact any individual fisherman, overall commercial revenue, or public recreational opportunities. Therefore, the Proposed Action would not result in significant cumulative socioeconomic impacts.

4.2.15 Environmental Justice and Protection of Children

Based on the analysis in Section 3.11, implementation of Proposed Action would have no disproportionate effect on minority or low-income population or expose environmental hazards to children. Therefore, no cumulative impacts would occur since the incremental impact of the Proposed Action is not significant when added to effects of the other projects considered for cumulative analysis.

4.2.16 Public Safety

Cumulative impacts on public safety would consist of the combined effects of the Proposed Action and other projects, actions, and processes that would result in increased public health and safety risks. Navy training poses risks to the public primarily through offsite aircraft and vessel activities, underwater detonations, and intrusion of the public into designated training areas. Aircraft and marine vessel support for Navy training activities would increase, but public safety is expected to be maintained through the continued issuance of NOTMARs and NOTAMS (see Section 3.16).

Cumulative impacts on Public Health and Safety would consist of the aggregate effects of the Proposed Action and other projects, actions, and processes that could increase risks to people within the Study Area. Relevant effects in marine areas would include danger from recreational and commercial fishing, ship collisions, and other natural ocean dangers. Relevant effects in terrestrial areas would include danger from hazardous training activities. The cumulative effects of these activities are known only in a very general sense.

Marine, terrestrial, and naval training activities could affect nearby individuals; however this potential is mitigated by thorough USCG regulations on the water, vehicle and traffic laws of surrounding areas, and local ordinances. Navy range clearance measures within the restricted areas and active monitoring for non-participant activity are mitigation measures established by the military to prevent harm. Training and support activities, such as aircraft and watercraft transiting to and from the training areas, have the most potential for impacts on public health and safety.

The Proposed Action and other activities performed and proposed by surrounding commercial, industrial, and recreational interests do not normally increase the risk of impacts on health and public safety resources. The incremental impacts of the Proposed Action do not represent any appreciable contribution to cumulative health and safety risks when added to other past, present, and reasonably foreseeable future actions. Therefore, there would be no cumulative effects on public health and safety from implementation of the Proposed Action when added to past, present, or planned projects in the Study Area.

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5 Mitigation

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5 MITIGATION MEASURES

Effective training in the proposed Northwest Training Range Complex (NWTRC) dictates that ship, submarine, and aircraft participants utilize their sensors and weapon systems to their optimum capabilities as required by the exercise objectives. The Navy recognizes that such use has the potential to cause behavioral disruption of some marine mammal species in the vicinity of training (as outlined in Chapter 3). National Environmental Policy Act (NEPA) regulations require that an Environmental Impact Statement (EIS) include analysis of appropriate mitigation measures not already included in the Proposed Action or alternatives (40 Code of Federal Regulations [CFR] § 1502.14 [h]). Each of the alternatives, including the Proposed Action considered in this EIS/Overseas EIS (OEIS), includes mitigation measures intended to reduce the environmental effects of Navy activities as discussed throughout this EIS/OEIS.

This chapter presents the Navy's standard protective measures in detail, outlining steps that would be implemented to protect marine mammals and federally listed species during training events. These protective measures will mitigate impacts resulting from training. It should be noted that protective measures have been standard operating procedures since 2004 for all levels of training. This chapter 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.

5.1 CURRENT REQUIREMENTS AND PRACTICES

5.1.1 Geology and Soils

The Navy currently monitors and will continue to monitor the condition of soils and vegetation in its operating areas. It also employs adaptive management to control erosion associated with the existing roads and ranges (DoN 2007). In addition to the site-specific measures above, existing plans and policies are in place to limit the effects of training on the environment at Seaplane Base Whidbey Island (DoN 1996).

The surface layers of disturbed soils have been modified during construction or removed for use as ballast or landfill material. The subsurface characteristics of the original soil have usually not been altered, and control the movement of water on and through the soils. Current Navy protective practices for geological and soil resources include:

- Locate ground-disturbing activities on previously disturbed sites whenever possible.
- Ensure that all project work areas, including transit routes necessary to reach sites, are clearly identified or marked. Restrict vehicular activities to designated/previously identified areas.
- Continue to manage erosion control through the Site Approval Process, whereby the Navy reviews each proposed project for its erosion potential, and involves the natural resource specialist in the process.
- Off-road vehicle use is not permitted except in designated off-road areas or on established trails.

5.1.2 Air Quality

Emissions that may affect air quality are heavily regulated under the Clean Air Act and its implementing regulations, through a comprehensive Federal / State regulatory process (see Section 3.2). Consistent with these regulatory requirements and processes, the Navy has implemented comprehensive air quality management programs to ensure compliance.

5.1.3 Hazardous Materials and Wastes

Releases or discharges of hazardous materials are heavily regulated through comprehensive federal and state processes. In addition, the International Convention for the Prevention of Pollution from Ships (MARPOL 73/78) prohibits certain discharges of oil, garbage, and other substances from vessels. The MARPOL convention is implemented by national legislation, including the Act to Prevent Pollution from Ships (33 USC 1901, et seq.) and the Federal Water Pollution Control Act ("Clean Water Act"; 33 USC 1321, et seq.). These and other requirements are implemented by the *Navy Environmental and Natural Resources Program Manual* (OPNAVINST 5090.1C, 2007) and related Navy guidance documents that require hazardous materials to be stored and handled appropriately, both on shore and afloat.

The Navy has also implemented hazardous materials management programs to ensure compliance and provide guidance on handling and disposing of such materials. Navy instructions include stringent discharge, storage, and pollution prevention measures and require facility managers to reduce, to the extent possible, quantities of toxic substances released into the environment. All Navy vessels and facilities have comprehensive programs in place that implement responsible stewardship, hazardous materials management and minimization, pollution prevention, recycling, and spill prevention and response. These and other programs allow Navy ships to retain used and excess hazardous material on board for shore offload within five working days of arrival at a Navy port. All activities can return excess and unused hazardous materials to the Navy's Hazardous Material Minimization Centers. Additional information regarding water discharge restrictions for Navy vessels is provided in Table 3.4-1, Water Resources.

The Navy currently monitors and will continue to monitor the condition of soils and vegetation in its operating areas (DoN 2007b). It also employs adaptive management to control erosion associated with the existing roads and ranges. In addition to the site-specific measures above, existing plans and policies are in place to limit the effects of training on the environment at Seaplane Base Whidbey Island (DoN 1996). Additional information regarding current Navy protective practices for geological and soil resources were previously discussed in Section 5.1.1, within the Geology and Soils section.

5.1.4 Water Resources

Environmental compliance policies and procedures applicable to operations ashore and at sea are identified in Navy instructions that include directives regarding waste management, pollution prevention, and recycling. The Navy's current requirements and practices provide protection for water resources. Measures that reduce potential impacts to water resources include creation and adherence to storm water management plans, erosion control, maintaining vegetative buffers adjacent to waterways, and enforcement of pollution permit requirements (NPDES).

At sea, Navy vessels are required to operate in a manner that minimizes or eliminates any adverse impacts to the marine environment. Environmental compliance polices and procedures applicable to shipboard operations afloat are defined in the *Navy Environmental and Natural Resources Program Manual* (OPNAVINST 5090.1C, 2007), Chapter 4, "Pollution Prevention," and Chapter 22, "Environmental Compliance Afloat"; DoD Instruction 5000.2-R (§C5.2.3.5.10.8, "Pollution Prevention") (DoN, 2003). In addition, provisions in Executive Order (EO) 12856, *Federal Compliance With Right-To-Know Laws and Pollution Prevention Requirements*, and EO 13101, *Greening the Government through Waste Prevention, Recycling, and Federal Acquisition* reinforce the CWA's prohibition against discharge of harmful quantities of hazardous substances into or upon U.S. waters out to 200 nm (371 km), and mandate stringent hazardous waste discharge, storage, dumping, and pollution prevention requirements. Table 3.4-1 provides information on Navy SOPs and BMPs for shipboard management, storage, and discharge of hazardous materials and wastes, and on other pollution protection measures intended to protect water quality. Onshore, policies and procedures related to spills of oil and hazardous materials are detailed in OPNAVISNT 5090.1C, Chapter 12.

Shipboard waste-handling procedures governing the discharge of non-hazardous waste streams have been established for commercial and Navy vessels. These categories of wastes include solids (garbage) and liquids such as “black water” (sewage), “grey water” (water from deck drains, showers, dishwashers, laundries, etc.), and oily wastes (oil-water mixtures). Table 5-1 summarizes the waste stream discharge restrictions for Navy vessels at sea.

Table 5-1: Waste Discharge Restrictions for Navy Vessels

Zone (nm from shore)	Type of Waste	
	Black Water (Sewage)	**Gray Water**
U.S. Waters (0-3 nm)	No discharge.	If vessel is equipped to collect gray water, pump out when in port. If no collection capability exists, direct discharge permitted.
U.S. Contiguous Zone (3-12 nm)	Direct discharge permitted.	Direct discharge permitted.
>12 nm from shore	Direct discharge permitted.	Direct discharge permitted.
Zone	**Oily Waste**	**Garbage (Non-plastic)**
U.S. Waters (0-3 nm)	Discharge allowed if waste has no visible sheen. If equipped with Oil Content Monitor (OCM), discharge < 15 ppm oil.	No discharge.
U.S. Contiguous Zone (3-12 nm)	Same as 0-3 nm.	Pulped garbage may be discharged.
>12 nm from shore	If equipped with OCM, discharge < 15 ppm oil. Vessels with Oil/Water Separator but no OCM must process all bilge water through the oil-water separator.	Direct discharge permitted.
Zone	**Garbage (Plastic) (Non-food-contaminated)**	**Garbage (Plastic) (food-contaminated)**
U.S. Waters (0-3 nm)	No discharge.	No discharge.
U.S. Contiguous Zone (3-12 nm)	No discharge.	No discharge.
12-50 nm from shore	No discharge.	No discharge.
> 50 nm from shore	Retain last 20 days before return to port. Discharge if necessary.	Retain last three days before return to port. Discharge if necessary.

Source: Northern Division 1996; Office of the Chief of Naval Operations 1994

5.1.5 Acoustic Environment (Airborne)

Navy activities in the NWTRC OPAREAs comply with numerous established acoustic control procedures to ensure that neither participants nor non-participants engage in activities that would endanger life or property. SOPs for minimizing airborne noise impacts in the NWTRC fall into two categories; aircraft SOPs and EOD SOPs.

Aircraft SOPs are largely oriented toward safety, which also provide significant noise abatement benefits. For example many SOPs involve flight routing and minimum altitudes. Each of these procedures increases the range of the noise source from human receptors, thus reducing noise impacts. As stated in DoN (2006), all training and operational flights are to be conducted to have a minimum impact on surrounding communities. Each aircrew shall be familiar with the noise profiles of their aircraft and shall be committed to minimizing noise impacts without compromising operational and safety requirements (DoN 2006).

EOD measures include the following for reducing noise impacts during land detonation training:

- Detonation training will be conducted only during normal working hours (8:00 AM to 5:00 PM).
- Detonation training will be conducted only during days when the weather is favorable. Studies have shown that variation of temperature and wind velocity with altitude can cause a noise event to be inaudible at one time (favorable) and audible at another time (unfavorable). Favorable and unfavorable conditions are described in Table 5-2.

Table 5-2. Favorable and Unfavorable Detonation Conditions

Favorable Conditions	Unfavorable Conditions
• Clear skies with billowy cloud formations, especially during warm periods of the day • A rising barometer immediately following a storm	• Days of steady winds of 5-10 mph with gusts of greater velocities (above 20 mph) in any direction • Clear days on which layering of smoke or fog are observed • Cold, hazy or foggy mornings • Days following a day when large extremes of temperature (greater than 20 degrees C) between day and night are noted • Generally high barometer readings with low temperatures

Military personnel who might be exposed to sound in the air from military activities, such as military aircraft, land detonations or at sea detonations heard on the surface of the ocean, are required to take precautions, such as the wearing of protective equipment, to reduce or eliminate potential harmful effects of such exposure. With regard to potential exposure of non-military personnel in the ocean, Puget Sound areas, and inland OPAREAs, precautions are taken pursuant to SOPs to prevent such exposure. These include advance notice of scheduled training activities to the public and the commercial fishing community via the worldwide web, Notices to Mariners (NOTMARs), and Notices to Airmen (NOTAMs). In addition, range safety SOPs ensure that civilians are excluded from, and if necessary removed from areas of military activities, or that military activities do not occur when civilians are present. These procedures have proven to be effective at minimizing potential military / civilian interactions in the course of training or other military activities.

5.1.6 Marine Plants and Invertebrates

The Navy has no existing protective measures in place specifically for marine plants and invertebrates. However, marine plants and invertebrates benefit from measures in place to protect marine mammals and sea turtles (see Section 5.1.8).

5.1.7 Fish

The following protective measures for fish and fish habitat exist for activities involving underwater detonations.

- At the Crescent Harbor and Indian Island Underwater EOD Ranges, during the juvenile salmonid migration season (July 1 through September 30), charges larger than 2.5 pounds will not be used. If it is necessary to use charges larger than 2.5 pounds, and up to 20 pounds, these charges will be detonated at least 3,280 feet from the nearest shoreline.
- At the Floral Point Underwater EOD Range, charges larger than one pound shall not be used during the juvenile salmonid migration season (March 15 through July 1).

5.1.8 Birds

Avoidance of seabirds and their nesting and roosting habitats provides the greatest degree of protective measure from potential impacts within the NWTRC. Currently, the majority of aircraft activities that might affect seabirds are concentrated at NASWI and Outlying Landing Field (OLF) Coupeville where the potential for bird aircraft strikes exists. Pursuant to Navy instruction, measures to evaluate and reduce of eliminate this hazard to aircraft, aircrews, and birds are implemented. Additionally, guidance involving land or water detonations contains instructions to personnel to observe the surrounding area within 600 yds (585 m) for 30 minutes prior to detonation. If birds (or marine mammals or sea turtles) are seen, the operation must be relocated to an unoccupied area or postponed until animals leave the area. Monitoring of seabird populations and colonies by conservation groups and researchers is conducted intermittently within coastal areas and offshore islands with limited support from various military commands. In an effort to reduce potential impacts to marbled murrelets, the Navy will conduct sea bird surveys. The Navy currently surveys for all seabirds and marine mammals that may be within the designated impact zone, the same “go, no go” status will be applicable to murrelets, as well.

5.1.9 Terrestrial Biological Resources

The Navy implements measures to avoid, minimize, or compensate for its effects on biological resources including listed species in the NWTRC. Key management and monitoring activities include continued implementation of the NASWI Integrated Natural Resources Management Plan (INRMP). Further, the Navy proposes to implement additional measures to mitigate the environmental effects of its activities. The following is a comprehensive list of current and proposed mitigation measures intended to reduce effects of military activities on biological resources of Whidbey Island.

5.1.9.1 Threatened and Endangered Species

There are no current protective measures designed specifically for threatened and endangered species.

5.1.9.2 Soils

The Navy will monitor and provide a means for adaptive management of erosion associated with the existing roads and ranges. In addition to the site-specific measures above, existing plans and policies are in place to limit the effects of construction and training on the environment at Seaplane Base Whidbey Island.

Additionally, because OLF Coupeville is managed as a federal property, activities are required to comply with the federal Soil Conservation Act. Federal land owners are required to control and prevent erosion by conducting surveys and implementing conservation measures (Soil Conservation Act, 16 U.S.C. § 5901).

Current Navy protective practices for geological and soil resources include:

- Locate ground-disturbing activities on previously disturbed sites whenever possible.
- Ensure that all project work areas, including transit routes necessary to reach sites, are clearly identified or marked. Restrict vehicular activities to designated/previously identified areas.
- Continue to manage erosion control through the Site Approval Process, whereby the Navy reviews each proposed project for its erosion potential, and involves the Natural Resource Specialist in the process.
- Off-road vehicle use is not permitted except in designated off-road areas or on established trails.

5.1.10 Cultural Resources

Section 3.12.1 details protective measures implemented with regard to cultural resources on Whidbey Island (submerged cultural resources in ocean areas are unaffected by Navy activities). In the open ocean, most of the Pacific Coast Treaty Tribal Fishing Grounds lie within the Olympic Coast National Marine Sanctuary, which is within Warning Areas W237A and W237B.

Base Cultural Resources Programs would strive to preserve and protect their cultural resource sites, including efforts to retain the integrity of cultural sites that, over time, could deteriorate, erode, or be damaged by human actions. Protective measures would include keeping current and future human activities off of known sites, or when this is not possible, minimizing impacts on those sites. Projects would consider the probability for occurrence of hunter-gatherer (prehistoric/protohistoric) resources in areas along the salt-water beaches, shell middens, or eroding shorelines.

Locations and extent of NRHP eligible/listed archaeological resources would not be made public or provided to navy personnel other than on a need to know basis until such time as they may be displayed and interpreted in a manner that provides protection from vandalism. Protective measures would be described in the Historic and Archaeological Resources Protection (HARP) Plan for the individual base, and compatible with HARP goals.

NRHP resources would be managed in a manner that is compatible with the military mission of the individual base and its tenant commands. Navy actions would be planned to avoid potential NRHP resources, including shipwrecks. Natural resources projects that involve ground disturbing activities would be processed through the HARP program manager to avoid damage to historic properties. Resource treatment would be cognizant of the base ICRMP.

Discovery of archaeological evidence of previous human occupation would cause work to stop on any base undertaking, the discovery would be protected from damage, and Federal, State, and tribal authorities would be notified as appropriate. The resource would be evaluated for NRHP significance (36 CFR 800), and mitigation measures developed in consultation with the State Historic Preservation Officer (SHPO) and, as appropriate, the Tribal Historic Preservation Officer (THPO).

For management purposes, sites deemed eligible for the NRHP would be treated in exactly the same manner as sites that are actually listed in the NRHP. Archaeological sites and historic structures and sites that have not been evaluated for NRHP significance would be considered eligible until evaluation is completed, and projects in areas where eligibility for the NRHP has not been determined would require coordination and consultation as proscribed in Section 106 of the NHPA.

Tribal Historic Preservation Officers or appropriate tribal representatives would be contacted prior to Navy undertakings in undeveloped areas. Consultation and coordination would aid in reducing potential impacts of intrusions on traditional practices. Traditional cultural properties would be protected through the Section 106 consultation process.

The Navy has established protective measures to reduce potential effects on cultural and natural resources from training exercises. Some are generally applicable, while others apply to particular geographic areas during specific times of year for certain types of Navy training activities. These measures are based on environmental analyses conducted by the Navy for coastal waters and for land and sea ranges.

Most of these protective measures are focused on protection of the natural environment. Such protective measures also benefit culturally valued natural resources such as salmon and shellfish. Some of the protective measures include use of inert ordnance and passive tracking and acoustical tools, avoidance of sensitive habitats, and visually monitoring areas to ensure significant concentrations of sea life are not present.

Areas along the northwest Washington coastline were designated in 2002 as an area to be avoided (ATBA) by ships and barges carrying oil or hazardous materials and by all ships 1,600 gross tons and above that are solely in transit. The ATBA has helped reduce near shore vessel traffic and traffic within the tribal treaty fishing grounds as well as helping to protect the Olympic Coast National Marine Sanctuary and its resources valued by tribes. This measure is voluntary and places no new requirements on Navy ships.

5.1.11 Traffic

The Navy strives to ensure that it retains access to ocean training areas and special use airspace (SUA) as necessary to accomplish its mission, while facilitating joint military-civilian use of such areas to the extent practicable and consistent with safety. These goals of military access, joint use, and safety are promoted through various coordination and outreach measures, including:

- Publication of NOTAM advising of the status and nature of activities being conducted in W-237, W-570, W-93, and other components of SUA in the NWTRC Study Area.
- Return of SUA to civilian Federal Aviation Administration (FAA) control when not in use for military activities. To accommodate the joint use of SUA, a Letter of Agreement is in place between the Navy and the Seattle Air Traffic Control Center (ARTCC). The LOA defines the conditions and procedures to ensure safe and efficient joint use of waning areas.
- Publication of NOTMAR and other outreach. The Navy provides information about training activities planned for the NWTRC OPAREAs, for publication by the U.S. Coast Guard in NOTMAR. Most such activities occur in offshore OPAREAs.

5.1.12 Socioeconomics

Given the nature and location of Navy activities addressed in this EIS/OEIS, mitigation and protective measures are unnecessary with respect to socioeconomic considerations.

5.1.13 Environmental Justice and Protection of Children

Given the nature and location of Navy activities addressed in this EIS/OEIS, mitigation and protective measures are unnecessary with respect to socioeconomic considerations.

5.1.14 Public Safety

Navy activities in the NWTRC comply with numerous established safety procedures to ensure the safety of participants and the public. Navy range managers have published safety procedures for activities on the offshore and nearshore areas (DoN 1997b, 1999, 2004). These guidelines are directive for range users. They provide, among other measures, that:

- Commanders are responsible for ensuring that impact areas and targets are clear prior to commencing activities that are hazardous.
- Aircraft or vessels expending ordnance shall not commence firing without permission of the OCE for their specific range area.
- Firing units and targets must remain in their assigned areas, and units must fire in accordance with current safety instructions.
- Ships are authorized to fire their weapons only in offshore areas and at specific distances from land, depending on the caliber and range of the weapons fired.
- The use of pyrotechnic or illumination devices and marine markers such as smoke or dye markers will be allowed only in the assigned areas, to avoid the launch of Search and Rescue forces when not required. Aircraft carrying ordnance to or from ranges shall avoid populated areas to the maximum extent possible.

- Aircrews operating in W-237, W-570, and W-93 are aware that non-participating aircraft are not precluded from entering the area and may not comply with a NOTAM or radio warning that hazardous activities are scheduled or occurring. Aircrews are required to maintain a continuous lookout for non-participating aircraft while operating under visual flight rules in the warning areas.

In addition to the above mentioned procedures, the Navy has instituted the following SOPs for use of the NWTRC:

5.1.14.1 Aviation Safety

Potential hazardous operations conducted within a Warning Area are conducted under visual flight rules (VFR) and under visual meteorological conditions. This means that the commanders of military aircraft are responsible for the safe conduct of their flight. Prior to releasing any weapons or ordnance, the impact area must be clear of non-participating vessels, people, or aircraft. The Officer in Charge of the Exercise (OCE) is ultimately responsible for the safe conduct of range training. A qualified Safety Officer is assigned to each training event or exercises and can terminate activities if unsafe conditions exist.

5.1.14.2 Submarine Safety

Vertical separation of at least 100 ft (30.5 m) is required between the top of a submarine's sail and the depth of a surface ship's keel. If a submarine (or submarine simulated target, the MK-30) is at periscope depth, at least a 1,500-yard (yd) (1,372-m) horizontal separation from other vessels must be maintained.

5.1.14.3 Surface Ship Safety

During training events, surface ships are required to obtain a "Green Range," which indicates that all safety criteria have been satisfied, and that the weapons and target recovery conditions and recovery helicopters and boats are ready to be employed.

5.1.14.4 Missile Exercise Safety

Safety is the top priority and paramount concern during missile exercises. These exercises can be surface-to-surface, subsurface-to-surface, surface-to-air, or air-to-air. A Missile Exercise (MISSILEX) Letter of Instruction is prepared prior to any missile firing exercise. This instruction establishes precise ground rules for the safe and successful execution of the exercise. Any MISSILEX participant who observes an unsafe situation can communicate a "Red Range" order over any voice communication systems.

5.2 MITIGATION MEASURES

In order to issue the Marine Mammal Protection Act (MMPA) authorization required for certain activities, it might be necessary for National Marine Fisheries Service (NMFS) to require additional mitigation or monitoring measures beyond those addressed above and elsewhere in the EIS/OEIS. These could include measures considered, but eliminated in the EIS/OEIS, or as yet developed measures. The public will have an opportunity to provide information to NMFS through the MMPA process, both during the comment period following NMFS' Notice of Receipt of the Navy's application for a Letter of Authorization (LOA), and during the comment period following publication of the proposed LOA. NMFS may propose additional mitigation or monitoring measures. Measures not considered in the mitigation and monitoring measures in this EIS/OEIS, but required through the MMPA process, might require evaluation in accordance with the National Environmental Policy Act. In doing so, NMFS may consider "tiering," that is, incorporating this EIS/OEIS during the MMPA process.

Resource areas requiring no additional mitigation measures include Geology and Soils, Air Quality, Hazardous Materials, Water Resources, Acoustic Environment, Marine Plants and Animals, Fish, Birds, Terrestrial Biological Resources, Cultural Resources, Traffic, Socioeconomics, Environmental Justice and Protection of Children, and Public Safety. The following section describes mitigation measures required for Sea Turtles and Marine Mammals.

5.2.1 Sea Turtles and Marine Mammals

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

This section includes protective and mitigation measures that are followed for all types of exercises; those that are associated with a particular type of training event; and those that apply to a particular geographic region or season. For exercises involving multiple units, the applicable mitigation measures are incorporated into a naval message which is disseminated to all of the units participating in the exercise or training event and applicable responsible commands. Appropriate measures are also provided to non-Navy participants (other DoD and allied forces) to ensure their use by these participants.

5.2.1.1 General Maritime Measures

Personnel Training – Watchstanders and Lookouts

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

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

- Navy lookouts will undertake extensive training in order to qualify as a watchstander in accordance with the Lookout Training Handbook (Naval Education and Training Command [NAVEDTRA] 12968-D).
- Lookout training will include on-the-job instruction under the supervision of a qualified, experienced 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 those listed below 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 chain of command in order to facilitate implementation of protective measures if marine species are spotted.

Operating Procedures & Collision Avoidance

- Prior to exercises involving multiple units, 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 protective 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, in addition to the three personnel on watch, surface vessels will have at least two lookouts with binoculars; surfaced submarines will have at least one lookout with binoculars. Lookouts already posted for safety of navigation and man-overboard precautions may be used to fill this requirement. As part of their regular duties, lookouts will watch for and report to the OOD the presence of marine mammals and sea turtles.
- On surface vessels equipped with a mid-frequency active sonar, pedestal mounted “Big Eye” (20x110) binoculars will be properly installed and in good working order to assist in the detection of marine mammals and sea turtles in the vicinity of the vessel.
- Personnel on lookout will employ visual search procedures employing a scanning methodology in accordance with the Lookout Training Handbook (NAVEDTRA 12968-D).
- After sunset and prior to sunrise, lookouts will employ Night Lookouts Techniques in accordance with the Lookout Training Handbook. (NAVEDTRA 12968-D).
- While in transit, naval vessels will be alert at all times, use extreme caution, and proceed at a “safe speed” so that the vessel can take proper and effective action to avoid a collision with any marine animal and can be stopped within a distance appropriate to the prevailing circumstances and conditions.
- When 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).
- Floating weeds and kelp, algal mats, clusters of seabirds, and jellyfish are good indicators of sea turtles and marine mammals. Therefore, increased vigilance in watching for sea turtles and marine mammals will be taken where these are present.
- Navy aircraft participating in exercises at sea will conduct and maintain, when operationally feasible and safe, surveillance for marine species of concern as long as it does not violate safety constraints or interfere with the accomplishment of primary operational duties. Marine mammal detections will be immediately reported to assigned Aircraft Control Unit for further dissemination to ships in the vicinity of the marine species as appropriate where it is reasonable to conclude that the course of the ship will likely result in a closing of the distance to the detected marine mammal.
- All vessels will maintain logs and records documenting training operations should they be required for event reconstruction purposes.

5.2.1.2 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 Marine Species Awareness Training material prior to use of mid-frequency active sonar.
- All COs, XOs, and officers standing watch on the bridge will have reviewed the Marine Species Awareness Training material prior to a training event employing the use of mid-frequency active sonar.
- Navy lookouts will undertake extensive training in order to qualify as a watchstander in accordance with the Lookout Training Handbook (Naval Educational Training [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). 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 will be responsible for reporting all objects or anomalies sighted in the water (regardless of the distance from the vessel) to the Officer of the Deck, since any object or disturbance (e.g., trash, periscope, surface disturbance, discoloration) in the water may be indicative of a threat to the vessel and its crew or indicative of a marine species that may need to be avoided as warranted.

Operating Procedures

- 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 activities, 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 yds (183 m) of the sonobuoy.
- Marine mammal detections will be immediately reported to assigned Aircraft Control Unit for further dissemination to ships in the vicinity of the marine species as appropriate where it is

reasonable to conclude that the course of the ship will likely result in a closing of the distance to the detected marine mammal.

- Safety Zones—When marine mammals are detected by any means (aircraft, shipboard lookout, or acoustically) within 1,000 yds (914 m) of the sonar dome (the bow), the ship or submarine will limit active transmission levels to at least 6 decibels (dB) below normal operating levels. (A 6 dB reduction equates to a 75 percent power reduction. The reason is that decibel levels are on a logarithmic scale, not a linear scale. Thus, a 6 dB reduction results in a power level only 25 percent of the original power.)
    - Ships and submarines will continue to limit maximum transmission levels by this 6-dB factor until the animal has been seen to leave the area, has not been detected for 30 minutes, or the vessel has transited more than 2,000 yds (1829 m) beyond the location of the last detection.
    - Should a marine mammal be detected within or closing to inside 500 yds (457 m) of the sonar dome, active sonar transmissions will be limited to at least 10 dB below the equipment's normal operating level. (A 10 dB reduction equates to a 90 percent power reduction from normal operating levels.) Ships and submarines will continue to limit maximum ping levels by this 10-dB factor until the animal has been seen to leave the area, has not been detected for 30 minutes, or the vessel has transited more than 2,000 yds (457 m) beyond the location of the last detection.
    - Should the marine mammal be detected within or closing to inside 200 yds (183 m) of the sonar dome, active sonar transmissions will cease. Sonar will not resume until the animal has been seen to leave the area, has not been detected for 30 minutes, or the vessel has transited more than 2,000 yds (457 m) beyond the location of the last detection.
    - Special conditions applicable for dolphins and porpoises only: If, after conducting an initial maneuver to avoid close quarters with dolphins or porpoises, the 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 shall follow the requirements as though they were operating at 235 dB—the normal operating level (i.e., the first power-down will be to 229 dB, regardless of at what level above 235 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.
- Sonar levels (generally)—Navy will operate MFA sonar at the lowest practicable level, not to exceed 235 dB, except as required to meet tactical training objectives.
- Helicopters shall observe/survey the vicinity of an ASW training event for 10 minutes before the first deployment of active (dipping) sonar in the water.
- Helicopters shall not dip their sonar within 200 yds (183 m) of a marine mammal and shall cease pinging if a marine mammal closes within 200 yds (183 m) after pinging has begun.
- Submarine sonar operators will review detection indicators of close-aboard marine mammals prior to the commencement of ASW training events involving active mid-frequency sonar.

Surface-to-Surface Gunnery (5-inch, 57 mm, 76 mm, 25 mm and .50 cal explosive rounds)

- Lookouts will visually survey for floating weeds and kelp, and algal mats which may be inhabited by immature sea turtles in the target area. Intended impact shall not be within 600 yds (585 m) of known or observed floating weeds and kelp, and algal mats.
- A 600 yard radius buffer zone will be established around the intended target.
- From the intended firing position, lookouts will survey the buffer zone for marine mammals and sea turtles prior to commencement and during the exercise as long as practicable. Due to the distance between the firing position and the buffer zone, lookouts are only expected to visually detect breaching whales, whale blows, and large pods of dolphins and porpoises.
- When manned, target towing vessels will maintain a lookout. If a marine mammal or sea turtle is sighted in the vicinity of the exercise, the tow vessel will immediately notify the firing vessel in order to secure gunnery firing until the area is clear.
- The exercise will be conducted only when the buffer zone is visible and marine mammals and sea turtles are not detected within the target area and the buffer zone.

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

- Lookouts will visually survey for floating weeds and kelp, and algal mats which may be inhabited by immature sea turtles in the target area. Intended impact will not be within 200 yds (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, lookouts will survey the buffer zone for marine mammals and sea turtles prior to commencement and during the exercise as long as practicable. Due to the distance between the firing position and the buffer zone, lookouts are only expected to visually detect breaching whales, whale blows, and large pods of dolphins and porpoises.
- When manned, target towing vessels will maintain a lookout. If a marine mammal or sea turtle is sighted in the vicinity of the exercise, the tow vessel will immediately notify the firing vessel in order to secure gunnery firing until the area is clear.
- The exercise will be conducted only when the buffer zone is visible and marine mammals and sea turtles are not detected within the target area and the buffer zone.

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

- Vessels will orient the geometry of gunnery exercises in order to prevent debris from falling in the area of sighted marine mammals and sea turtles.
- Vessels will expedite the recovery of any parachute deploying aerial targets to reduce the potential for entanglement of marine mammals and sea turtles.
- Target towing aircraft shall maintain a lookout. If a marine mammal or sea turtle 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 non-explosive rounds)

- If surface vessels are involved, lookouts will visually survey for floating kelp, which may be inhabited by immature sea turtles, in the target area. Impact should not occur within 200 yds (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 and sea turtles prior to and during the exercise.
- Aerial surveillance of the buffer zone for marine mammals and sea turtles will be conducted prior to commencement of the exercise. Aerial surveillance altitude of 500 feet to 1,500 ft (152 - 456 m) is optimum. Aircraft crew/pilot will maintain visual watch during exercises. Release of ordnance through cloud cover is prohibited: aircraft must be able to actually see ordnance impact areas.
- The exercise will be conducted only if marine mammals and sea turtles are not visible within the buffer zone.

Air-to-Surface At-Sea Bombing Exercises (explosive and non-explosive bombs and cluster munitions, rockets)

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

Air-to-Surface Missile Exercises (explosive and non-explosive)

- Ordnance shall not be targeted to impact within 1,800 yds (1,646 m) of known or observed floating kelp, which may be inhabited by immature sea turtles.
- Aircraft will visually survey the target area for marine mammals and sea turtles. Visual inspection of the target area will be made by flying at 1,500 (457 m) feet 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 shall not be targeted to impact within 1,800 yds (1646 m) of sighted marine mammals and sea turtles.

Underwater Detonations (up to 20-lb charges)

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

Exclusion Zones

All Mine Warfare and Mine Countermeasures activities involving the use of explosive charges must include exclusion zones for marine mammals and sea turtles to prevent physical and/or acoustic effects to those species. These exclusion zones shall extend in a 700-yard (640 m) arc radius around the detonation site.

Pre-Exercise Surveys

For Demolition and Ship Mine Countermeasures activities, pre-exercise survey shall be conducted within 30 minutes prior to the commencement of the scheduled explosive event. The survey may be conducted from the surface, by divers, and/or from the air, and personnel shall be alert to the presence of any marine mammal or sea turtle. Should such an animal be present within the survey area, the exercise shall be paused until the animal voluntarily leaves the area. The Navy will suspend detonation exercises and ensure the area is clear for a full 30 minutes prior to detonation. Additionally, the Navy implements a 30 minute time limit between subsequent detonations during the same activity. Personnel will record any protected species marine mammal and sea turtle observations during the exercise as well as measures taken if species are detected within the exclusion zone.

Post-Exercise Surveys and Reporting

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

If there is evidence that a marine mammal or sea turtle may have been stranded, injured or killed by the action, Navy training activities will be immediately suspended and the situation immediately reported by the participating unit to the OCE, who will follow Navy procedures for reporting the incident to Commander, Pacific Fleet, Commander, Navy Region Northwest, Regional Operations Center (ROC) at 360-315-0123 (24/7) who will immediately contact the Regional environmental Support Office (N40), and the chain-of-command.

Sinking Exercise

The selection of sites suitable for a Sinking Exercises (SINKEXs) involves a balance of operational suitability, requirements established under the Marine Protection, Research and Sanctuaries Act (MPRSA) permit granted to the Navy (40 Code of Federal Regulations § 229.2), and the identification of areas with a low likelihood of encountering Endangered Species Act (ESA) listed species. To meet operational suitability criteria, locations must be within a reasonable distance of the target vessels' originating location. The locations should also be close to active military bases to allow participating assets access to shore facilities. For safety purposes, these locations should also be in areas that are not generally used by non-military air or watercraft. The MPRSA permit requires vessels to be sunk in waters which are at least 1,000 fathoms (3,000 yds / 2742 m)) deep and at least 50 nm from land.

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

SINKEX Mitigation Plan

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

- All weapons firing would be conducted during the period 1 hour after official sunrise to 30 minutes before official sunset.
- Extensive range clearance activities would be conducted in the hours prior to commencement of the exercise, ensuring that no shipping is located within the hazard range of the longest-range weapon being fired for that event.
- An exclusion zone with a radius of 1.0 nm would be established around each target. This exclusion zone is based on calculations using a 990-pound (lb) H6 net explosive weight high explosive source detonated 5 ft below the surface of the water, which yields a distance of 0.85 nm (cold season) and 0.89 nm (warm season) beyond which the received level is below the 182

decibels (dB) re: 1 micropascal squared-seconds (μPa2-s) threshold established for the WINSTON S. CHURCHILL (DDG 81) shock trials (U.S. Navy, 2001). An additional buffer of 0.5 nm would be added to account for errors, target drift, and animal movements. Additionally, a safety zone, which extends from the exclusion zone at 1.0 nm out an additional 0.5 nm, would be surveyed. Together, the zones extend out 2 nm from the target.

- A series of surveillance over-flights would be conducted within the exclusion zone prior to and during the exercise, and within the safety zone when feasible. Survey protocol would be as follows:
  - Overflights within the exclusion zone would be conducted in a manner that optimizes the surface area of the water observed. This may be accomplished through the use of the Navy's Search and Rescue Tactical Aid, which provides the best search altitude, ground speed, and track spacing for the discovery of small, possibly dark objects in the water based on the environmental conditions of the day. These environmental conditions include the angle of sun inclination, amount of daylight, cloud cover, visibility, and sea state.
  - All visual surveillance activities would be conducted by Navy personnel trained in visual surveillance. At least one member of the mitigation team would have completed the Navy's marine mammal training program for lookouts.
  - In addition to the overflights, the exclusion zone would be monitored by passive acoustic means, when assets are available. This passive acoustic monitoring would be maintained throughout the exercise. Potential assets include sonobuoys, which can be utilized to detect any vocalizing marine mammals (particularly sperm whales) in the vicinity of the exercise. The sonobuoys would be re-seeded as necessary throughout the exercise. Additionally, passive sonar onboard submarines may be utilized to detect any vocalizing marine mammals in the area. The OCE would be informed of any aural detection of marine mammals and would include this information in the determination of when it is safe to commence the exercise.
  - On each day of the exercise, aerial surveillance of the exclusion and safety zones would commence 2 hours prior to the first firing.
  - The results of all visual, aerial, and acoustic searches would be reported immediately to the OCE. No weapons launches or firing would commence until the OCE declares the safety and exclusion zones free of marine mammals and threatened and endangered species.
  - If a marine mammal or sea turtle is observed within the safety zone, the observing aircraft would monitor them to ensure they remain outside of the exclusion zone.
  - If a marine mammal or sea turtle is observed within the exclusion zone is diving, firing would be delayed until the animal is re-sighted outside the exclusion zone, or 30 minutes have elapsed. After 30 minutes, if the animal has not been re-sighted it would be assumed to have left the exclusion zone. This is based on a typical dive time of 30 minutes for traveling listed species of concern. The OCE would determine if the listed species is in danger of being adversely affected by commencement of the exercise.
  - During breaks in the exercise of 30 minutes or more, the exclusion zone would again be surveyed for any protected species. If protected species are sighted within the exclusion zone, the OCE would be notified, and the procedure described above would be followed.
  - Upon sinking of the vessel, a final surveillance of the exclusion zone would be monitored for 2 hours, or until sunset, to verify that no listed species were harmed.

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

Mitigation Measures Related to Explosive Source Sonobuoys (AN/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 should be conducted below 1500 ft at a slow speed when operationally feasible and weather conditions permit. In dual aircraft operations, crews may conduct coordinated area clearances.
- Crews shall conduct a minimum of 30 minutes of visual and aural monitoring of the search area prior to commanding the first post (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 will be deployed within 1000 yds of observed marine mammal activity, crews will deploy the receiver ONLY and monitor while conducting a visual search. When marine mammals are no longer detected within 1000 yds of the intended post position, crews will collocate the AN/SSQ-110A sonobuoy (source) with the receiver.
- When operationally feasible, crews will conduct continuous visual and aural monitoring of marine mammal activity, including monitoring of their aircraft sensors from first sensor placement to checking off-station and out of RF range of the sensors.

AN/SSQ-110A Pattern Employment

- Aural Detection:
    - Aural detection of marine mammals cues the aircrew to increase the diligence of their visual surveillance.
    - If, following aural detection, no marine mammals are visually detected, then the crew may continue multi-static active search.

- Visual Detection:
    - If marine mammals are visually detected within 1000 yds of the AN/SSQ-110A sonobuoy intended for use, then that payload shall not be detonated. Aircrews may utilize this post once the marine mammals have not been re-sighted for 30 minutes or are observed to have moved outside the 1000 yd safety zone.
    - Aircrews may shift their multi-static active search to another post, where marine mammals are outside the 1000 yd safety zone.

AN/SSQ-110A Scuttling Sonobuoys

- Aircrews shall make every attempt to manually detonate the unexploded charges at each post in the pattern prior to departing the operations area by using the "Payload 1 Release" command followed by the "Payload 2 Release" command. Aircrews shall refrain from using the "Scuttle" command when two payloads remain at a given post. Aircrews will ensure a 1000 yd safety zone, visually clear of marine mammals, is maintained around each post as is done during active search operations.
- Aircrews shall only leave posts with unexploded charges in the event of a sonobuoy malfunction, an aircraft system malfunction, or when an aircraft must immediately depart the area due to issues such as fuel constraints, inclement weather, and in-flight emergencies. In these cases, the sonobuoy will self-scuttle using the secondary method or tertiary method.
- Aircrews ensure all payloads are accounted for. Sonobuoys that cannot be scuttled shall be reported as unexploded ordnance via voice communications while airborne and, upon landing, via Naval message.
- Mammal monitoring shall continue until out of their aircraft sensor range.

5.2.1.3 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, with AFAST being a major component of the overall monitoring program.

The primary goals of the ICMP are to:

- Monitor Navy training events, particularly those involving MFA sonar and underwater detonations, for compliance with the terms and conditions of ESA Section 7 consultations or 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 (goals b, c, and d may contribute to this goal).
- 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.
- For monitoring directly related to mitigation - an increase in the probability of detecting marine mammals, thus allowing for more effective implementation of the mitigation measures (shut-down zone, etc.).

Monitoring

- An increase in the probability of detecting marine mammals, both within the safety zone (thus allowing for more effective implementation of the mitigation) and in general to generate more data to contribute to the effects analyses.
- An increase in our understanding of how many marine mammals are likely to be exposed to levels of MFA sonar/HFA sonar (or explosives or other stimuli) that we associate with specific adverse effects, such as behavioral harassment, TTS, or PTS.
- An increase in our understanding of how marine mammals respond to MFA sonar/HFA sonar (at specific received levels), explosives, or other stimuli expected to result in take and how anticipated adverse effects on individuals (in different ways and to varying degrees) may impact the population, species, or stock (specifically through effects on annual rates of recruitment or survival)
- An increased knowledge of the affected species

- An increase in our understanding of the effectiveness of certain mitigation and monitoring measures

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

Research

The Navy provides a significant amount of funding and support to marine research. In the past five years the agency funded over $100 million ($26 million in FY08 alone) to universities, research institutions, federal laboratories, private companies, and independent researchers around the world to study marine mammals. The U.S. Navy sponsors seventy 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.

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

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

Monitoring: NWTRC Marine Species Monitoring Plan

The Navy has developed a Marine Species Monitoring Plan (MSMP) that provides recommendations for site-specific monitoring for MMPA and ESA listed species (primarily marine mammals) within the NWTRC, including during training exercises. The primary goals of monitoring are to evaluate trends in marine species distribution and abundance in order to assess potential population effects from Navy training activities and determine the effectiveness of the Navy's mitigation measures. The information gained from the monitoring will also allow the Navy to evaluate the models used to predict effects to marine mammals.

By using a combination of monitoring techniques or tools appropriate for the species of concern, type of Navy activities conducted, sea state conditions, and the size of the Range Complex, the detection, localization, and observation of marine mammals and sea turtles can be maximized. The following available monitoring techniques and tools are described in this monitoring plan for monitoring for range events (several days or weeks) and monitoring of population effects such as abundance and distribution (months or years):

- Visual Observations – Vessel-, Aerial- and Shore-based Surveys (for marine mammals and sea turtles) will provide data on population trends (abundance, distribution, and presence) and response of marine species to Navy training activities. Navy lookouts will also record observations of detected marine mammals from Navy ships during appropriate training and test events.

- Acoustic Monitoring – Passive Acoustic Monitoring possibly using towed hydrophone arrays, Autonomous Acoustic Recording buoys and U.S. Navy Instrument Acoustic Range (for marine mammals only) may provide presence/absence data on cryptic species that are difficult to detect visually (beaked whales and minke whales) that could address long term population trends and response to Navy training exercises.

- Additional Methods – Oceanographic Observations and Other Environmental Factors will be obtained during ship-based surveys and satellite remote sensing data. Oceanographic data is important factor that influences the abundance and distribution of prey items and therefore the distribution and movements of marine mammals.

The monitoring plan will be reviewed annually by Navy biologists to determine the effectiveness of the monitoring elements and to consider any new monitoring tools or techniques that may have become available.

5.2.1.4 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.

5.2.1.5 Alternative Mitigation Measures Considered but Eliminated

As described in Chapter 3, Section 3.9 and Appendix E, the vast majority of estimated sound exposures of marine mammals during proposed active sonar activities would not cause injury. Potential acoustic effects on marine mammals would be further reduced by the mitigation measures described above. 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 consideration of personnel safety, practicality of implementation, and impact on the effectiveness of the military readiness activity in consultation with the DoD. Therefore, the following additional mitigation measures were analyzed and eliminated from further consideration:

Augmenting Navy lookouts on Navy vessels providing surveillance of ASW or other training events with non-Navy personnel:

Augmenting Navy lookouts on Navy vessels providing surveillance of ASW or other training events with non-Navy personnel: The protection of marine mammals is provided by a lookout sighting the mammal and prompting immediate action. The premise that Navy personnel cannot or will not do this is unsupportable. Navy lookouts are extensively trained in spotting items at or near the water surface and relaying the information to their superiors who initiate action. Navy lookouts utilize their skills more frequently than many third-party trained non-Navy marine mammal observers. Use of Navy lookouts is the most effective means to ensure quick and efficient communication within the command structure, thus ensuring timely implementation of any relevant mitigation measures. A critical skill set of effective Navy training is communication via the chain of command. Navy lookouts are trained to report swiftly and decisively using precise terminology to ensure that critical information is passed to the appropriate supervisory personnel. Furthermore, available berthing space, integration of non-Navy personnel into the command structure, and security issues would present added challenges.

Employing non-Navy observers on non-military aircraft or vessels:

The Final EIS/OEIS concluded that measures in this category do not result in increased protection to marine mammals because the size of the areas, the time it takes to survey, and the movement of marine mammals preclude real-time mitigation. Recognizing that ASW training events could occur throughout the entire PACNW OPAREA (consisting of approximately 122,400 nm^2 [420,163 km^2]), contiguous ASW events may cover many hundreds of square miles in a few hours. Event participants are usually not visible to each other (separated by many tens of miles) and are constantly in motion. The number of civilian ships and/or aircraft required to monitor the area around these events would be considerable. In addition to practical concerns, surveillance of an exercise area during an event raises safety issues. Multiple, land-based, slow civilian aircraft operating in the same airspace as military aircraft will limit both the time available for civilian aircraft to be in the training area and present a concern should such aircraft experience mechanical problems. Scheduling of civilian vessel or aircraft surveillance also presents concerns, as exercise event timetables cannot be precisely fixed but develop freely from the flow of the tactical situation, thus mimicking real combat action. Waiting for civilian aircraft or vessels to complete surveys, refuel, or be on station would interrupt the necessary spontaneity of the exercise and would negatively impact the effectiveness of the military readiness activity. The Navy is committed to maintaining its marine mammal surveillance capability using both Navy surface and, to the extent that aviation assets are participants in the training activity, aerial monitoring.

Avoiding habitats and complex/steep bathymetry, including seamounts, and employing seasonal restrictions:

Seamounts are 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 with MFA sonar. Exercise locations are carefully chosen by planners based on training requirements and the ability of ships, aircraft, and submarines to operate safely. However, the full habitat requirements for most marine mammals in the NWTRC are unknown. Accordingly, there is insufficient information available regarding possible alternative exercise locations or environmental factors that would be less important to marine mammals in the NWTRC. When available, it must be factored with other considerations including safety and access to land ranges and facilities.

Avoidance of the seasonal presence of migrating marine mammals fails to take into account the fact that the Navy's current mitigation measures apply to all detected marine mammals no matter the season. Limiting training activities to fewer than 12 months of the year would not only concentrate all annual training and testing activities into a shorter time period, but would also not meet the readiness requirements of the Navy's mandate to deploy trained forces as might be required by unscheduled real world events.

Avoiding seamounts without exception fails to define scientific parameters for seamounts critical to marine mammals, such as a critical depth from the surface, and it is impossible to establish scientifically what would constitute a buffer that would avoid these areas. In addition, without a scientifically derived definition, there is no means to implement any proposed mitigation measure based on avoidance of seamounts.

Avoidance of steep or complex bathymetry in the NWTRC ignores the fact that there are numerous features and a variety of complex bathymetry in the NWTRC. Many of these areas of complex bathymetry and seamounts are in the very locations where Navy trains, and are valuable to Navy training. The purported need for this suggested mitigation measure is based on findings from other areas of the world that do not have direct application to the unique environment present in the NWTRC (e.g., the circumstances surrounding the 2000 Bahamas mass-stranding event). Ultimately, the Navy needs to train in representative environments, including near seamounts and in areas of steep or complex bathymetry, as submarines use these environments to avoid detection. Not being allowed to conduct exercises in these areas would have an unacceptable impact on training effectiveness.

Avoiding MFA and HFA sonar use within 12 nm from shore or, in the alternative, 15.5 miles (25 kilometers) from the 200-meter isobath:

During a recent major exercise in Hawaii (RIMPAC 2006), this mitigation measure precluded ASW training in the littoral region, which had a significant impact on realism and training effectiveness. There is no scientific evidence that any set distance from the coast is more protective of marine mammals than any other distance. The Navy has also determined that limiting MFA sonar use to outside 12 nm from the coast prevented crew members from gaining critical experience in training in shallow waters, and training in littoral waters. Sound propagates differently in shallower water. In real world events, it is highly likely crew members would be working in these types of areas, and these are the types of areas where diesel-electric submarines would be operating. Without the critical training near shore that ASW exercises provide, crews will not have the experience needed to successfully operate sonar in these types of waters, impacting vital military readiness.

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.

Suspending training at night, periods of low visibility and in high sea-states when marine mammals are not readily visible:

It is imperative that the Navy train to be able to operate at night, in periods of low visibility, and in high sea-states using the full potential of MFA or HFA sonar as a sensor. Anti-submarine warfare requires many hours and days for the situation to develop, to be identified and for the forces to respond. It would be extremely impracticable and unrealistic for the Navy's forces at sea to train only in daylight hours or to wait for weather to clear. Naval forces must train during all conditions to ensure they understand how constantly changing environmental conditions (including changes between day and night) affect sonar's capabilities and their ability to detect and maintain contact with submerged objects. The naval forces must constantly identify those changing conditions and adapt to them.

Maneuvering a vessel at night and during restricted visibility is not a simple activity. Navy vessels use radar and night vision devices to detect any object, whether a marine mammal, a periscope of an adversary submarine, trash, debris, or another surface vessel. Under the International Navigation Rules of the Road, periods of fog, mist, falling snow, heavy rainstorm, sandstorms, or any similar events are referred to as "restricted visibility." In restricted visibility, all mariners, including Navy vessel crews, are required to maintain proper look-out 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." Therefore, Navy vessels are required to use all means available in restricted visibility, including sonar and positioning of additional lookouts for heightened vigilance to avoid collision. Navy vessels use radar and night vision goggles to avoid any object, whether a marine mammal, a periscope of an adversary submarine, trash, debris, or another surface vessel. Prohibiting or limiting vessels from using MFA sonar during periods of restricted visibility therefore violates international navigational rules, increases navigational risk, and jeopardizes the safety of the ship and crew.

Reducing power in significant surface ducting conditions:

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 because the unit would be operating differently than it would during actual warfare.

Additionally, and significantly, the necessary information regarding 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 NWTRC exercise area, the determination of "significant surfacing ducting" is continually changing, and this mitigation measure could not be accurately implemented.

Furthermore, surface ducting alone does not 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 at 1,000 meters, even in significant surface ducting conditions. There is no scientific evidence that this mitigation measure is effective or that it provides additional protection for marine mammals beyond that afforded by an appropriate safety zone.

Reduction of MFA sonar power levels by 6 dB to 10 dB results in a 50- to 80-percent reduction of detection of submarines in the area due to a decrease in power of 75 to 90 percent. This means reduction of sonar power levels results in an inability to detect submarines at greater distances which reflect real world situations. As submarines are capable of striking ships at distances greater than a powered-down sonar would be able to detect, effective training is compromised.

The requirement under the current MMPA national defense exemption to consider significant surface ducting as part of an aggregate of conditions in planning major exercises does not apply in the NWTRC because those conditions do not exist in the aggregate. Normal safety zone requirements always apply.

Scaling down training to meet core aims:

As with each Navy range complex, the primary mission of the NWTRC 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 NWTRC.

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 the Strike Group to defend itself 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.

Passive acoustic detection and location of marine mammals:

As noted above, the Navy uses its passive detection capabilities to the maximum extent practicable consistent with the mission requirements to alert training participants to the presence of marine mammals in an event location.

Using "ramp-up" of MFA sonar to clear an area prior to the conduct of ASW training events:

Ramp-up procedures involve slowly increasing the sound in the water to levels that would clear an area of marine mammals prior to training at nominal source levels. 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 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 the ship. 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.

Ramp-up procedures purportedly provide marine mammals the opportunity to leave the area. There is no evidence that ramp-up procedures achieve the desired effect of causing the marine mammal to leave the area. Instead, it is well proven that dolphins ride the bow-waves of all vessels, including those employing MFA sonar, which indicates that some species of marine mammals do not flee.

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.

Using new technology (e.g., unmanned reconnaissance aircraft, underwater gliders, and instrumented ranges) to detect and avoid marine animals:

Although the Navy works with many new technologies, they presently remain unproven and limited in availability. The Navy has been collecting data using the hydrophones at underwater instrumented ranges to collect passive acoustic data on marine mammals. The Navy is working to develop the capability to detect and localize vocalizing marine mammals using these sensors, but based on the current status of acoustic monitoring science, it is not yet possible to use installed systems as mitigation tools. Similarly, research involving a variety of other methodologies (e.g., underwater gliders, radar, and lasers) is not yet developed to the point where they are effective or could be used as an actual mitigation tool.

Using larger shut-down zones:

The current power down and shut down zones are based on scientific investigations specific to MFA sonar for a representative group of marine mammals. 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. These safety zone distances were based on experiments involving distances at which the onset of TTS and PTS were identified. They are also supported by the scientific community. The safety zone the Navy has developed is also based on a lookout's ability to realistically maintain situational awareness over a large area of the ocean, 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 practicable. 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, do not provide any appreciable benefit to marine mammals and severely impact realistic ASW training. For example, increasing the shutdown zone for example from 200 yards to 2,187 yards contains 121 times the area of the Navy's current 200-yard shutdown zone. This restriction could increase 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 responsible for locating, tracking, and attacking a hostile submarine could lose awareness of the tactical situation through the constant 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 an attack.

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 NWTRC. 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.

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 as the Navy.

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6 Other Considerations

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6 OTHER CONSIDERATIONS REQUIRED BY THE NATIONAL ENVIRONMENTAL POLICY ACT

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

Based on an evaluation with respect to consistency with statutory obligations, the Department of the Navy's (DoN) alternatives including the Proposed Action ("Proposed Action") for the Northwest Training Range Complex (NWTRC) Draft Environmental Impact Statement (EIS) / Overseas Environmental Impact Statement (OEIS), hereby referred to as EIS/OEIS, does not conflict with the objectives or requirements of Federal, State, regional, or local plans, policies, or legal requirements. Table 6-1 provides a summary of environmental compliance requirements that may apply.

Table 6-1: Summary of Environmental Compliance for the Proposed Action

Plans, Policies, and Controls	Responsible Agency	Status of Compliance
National Environmental Policy Act (NEPA) of 1969 (42 U.S.C §§ 4321 *et seq*.) Council on Environmental Quality (CEQ) Regulations for Implementing the Procedural Provisions of NEPA (40 C.F.R. §§ 1500-1508) DoN Procedures for Implementing NEPA (32 C.F.R. § 775)	DoN	This EIS/OEIS has been prepared in accordance with NEPA, CEQ regulations and Navy NEPA procedures. Public participation and review is being conducted in compliance with NEPA.
Executive Order 12114, 32 CFR 187, Environmental Effects Abroad of Major Federal Actions	DoN	This EIS/OEIS has been prepared in accordance with EO 12114 as implemented by 32 CFR 187, which requires environmental consideration for actions that may affect the environment outside of U.S. Territorial Waters on the high seas.
Clean Air Act (CAA) (42 USC §§ 7401 *et seq*.) CAA General Conformity Rule (40 C.F.R. § 93[B]) State Implementation Plan (SIP)	U.S. Environmental Protection Agency (USEPA) Washington Department of Ecology Oregon Department of Environmental Quality California Air Resources Board North Coast Unified Air Quality Management District	The Proposed Action would not conflict with attainment and maintenance goals established in SIPs. A CAA conformity determination will not be required because emissions attributable to the alternatives including the Proposed Action would be below *de minimis* thresholds.
Federal Water Pollution Control Act (Clean Water Act [CWA)]) (33 U.S.C. §§ 1344 *et seq.*)	USEPA	No permits are required under the CWA Sections 401, 402, or 404 (b) (1).
Rivers and Harbors Act (33 U.S.C.§§ 401 et seq.)	U.S. Army Corps of Engineers	No permit is required under the Rivers and Harbors Act.

Table 6-1: Summary of Environmental Compliance for the Proposed Action (cont'd)

Plans, Policies, and Controls	Responsible Agency	Status of Compliance
Coastal Zone Management Act (CZMA) (16 C.F.R. §§ 1451 *et seq*.)	Washington State Department of Ecology Oregon Department of Land Conservation and Development California Coastal Commission	See Section 6.1.1, below, for discussion of Navy activities and compliance with the CZMA.
Magnuson-Stevens Fishery Conservation and Management Act (16 U.S.C. §§ 1801-1802)	National Marine Fisheries Service (NMFS)	The Proposed Action would not adversely affect Essential Fish Habitat (EFH) and would not decrease the available area or quality of EFH.
Endangered Species Act (ESA) (16 U.S.C. §§ 1531 et seq.)	DoN U.S. Fish and Wildlife Service (USFWS) NMFS	The EIS/OEIS analyzes potential effects to species listed under the ESA. In accordance with ESA requirements, the Navy will complete consultation under Section 7 of the ESA with NMFS and USFWS on the potential that implementation of the Proposed Action may affect listed species. With regard to NMFS jurisdiction, upon concluding Section 7 consultation, the Navy will adhere to any Biological Opinion (BO). In addition, the Navy will apply for a Letter of Authorization (LOA) (see discussion below re: Marine Mammal Protection Act), which is expected to impose terms and conditions that, when implemented, would make ESA Section 9 prohibitions inapplicable to covered Navy activities. With regard to USFWS jurisdiction over species present in the NWTRC, the Navy will initiate Section 7 consultation and conduct its activities in accordance with any applicable BOs.
Marine Mammal Protection Act (MMPA) (16 U.S.C. §§ 1431 *et seq*.)	NMFS	The MMPA governs activities with the potential to harm, disturb, or otherwise "harass" marine mammals. As a result of acoustic effects associated with mid-frequency active sonar use and underwater detonations of explosives, implementation of the alternatives including the Proposed Action may result in potential Level A (harm) or Level B (disturbance) harassment to marine mammals. Therefore, the Navy will engage NMFS in the regulatory process to determine whether incidental "takes" of marine mammals are likely, and seek a LOA from NMFS to permit takes as appropriate.
The Sikes Act of 1960 (16 U.S.C. §§ 670a-670o, as amended by the Sikes Act Improvement Act of 1997, Pub. L. No. 105-85)	DoD	The alternatives including the Proposed Action would be implemented in accordance with the management and conservation criteria developed in the Sikes Act Integrated Natural Resources Management Plans (INRMP) for Whidbey Island Naval Base Kitsap-Bangor, and Naval Magazine Indian Island.
Migratory Bird Treaty Act (16 U.S.C. §§ 703-712)	USFWS	Implementation of the alternatives including the Proposed Action would not have a significant impact on any population of migratory birds; would comply with the MBTA; and would not require a permit under the MBTA.

Table 6-1: Summary of Environmental Compliance for the Proposed Action (cont'd)

Plans, Policies, and Controls	Responsible Agency	Status of Compliance
The National Marine Sanctuaries Act (16 U.S.C. §§ 1431 et. seq.)	National Oceanic and Atmospheric Administration	Olympic Coast National Marine Sanctuary (OCNMS) lies within the Study Area addressed in this EIS/OEIS. Per OCNMS regulations (15 CFR §922.152(d)(1): "All Department of Defense military activities shall be carried out in a manner that avoids to the maximum extent practicable any adverse impacts on Sanctuary resources and qualities." (i) Except as provided in paragraph (d)(2) [bombing within the sanctuary], the prohibitions of this section do not apply to the following military activities performed by the Department of Defense in W–237A, W–237B, and Military Operating Areas Olympic A and B in the Sanctuary: (A) Hull integrity tests and other deep water tests; (B) Live firing of guns, missiles, torpedoes, and chaff; (C) Activities associated with the Quinault Range including the in-water testing of non-explosive torpedoes; and (D) Anti-submarine warfare operations. (ii) New activities may be exempted from the prohibitions in paragraphs (a) (2) through (7) of this section [discharging material, affecting cultural resources, drilling or altering the seabed, taking protected species, low overflight for certain areas, or interfering with investigation of possible NMS Act violation] by the Director after consultation between the Director and the Department of Defense. If it is determined that an activity may be carried out, such activity shall be carried out in a manner that avoids to the maximum extent practicable any adverse impact on Sanctuary resources and qualities. Civil engineering and other civil works projects conducted by the U.S. Army Corps of Engineers are excluded from the scope of this paragraph (d). Therefore, proposed activities are consistent with those activities currently conducted in the OCNMS, are consistent with those described in the designation document, and are not being changed or modified in a way that would require consultation. Implementation of the alternatives including the Proposed Action would have no effect on sanctuary resources in the off-shore environment of Washington. Review of agency actions under Section 304 of the National Marine Sanctuaries Act is not required.

Table 6-1: Summary of Environmental Compliance for the Proposed Action (cont'd)

Plans, Policies, and Controls	Responsible Agency	Status of Compliance
National Historic Preservation Act (NHPA) (16 U.S.C. §§ 470 *et seq*.)	DoN	The alternatives including the Proposed Action would be implemented in consultation with and under programmatic agreement with the State Historic Preservation Office, and pursuant to the criteria developed in the Integrated Cultural Resources Management Plans (ICRMP) for Whidbey Island.
EO 12898, Federal Actions to Address Environmental Justice in Minority Populations and Low-Income Populations	DoN	The Proposed Action would not result in any disproportionately high adverse human health or environmental effects on minority or low-income populations.
EO 13045, Protection of Children from Environmental Health Risks and Safety Risks	DoN	The Proposed Action would not result in environmental health and safety risks to children.
EO 13112, Invasive Species	DoN	EO 13112 requires agencies to identify actions that may affect the status of invasive species and take measures to avoid introduction and spread of these species. To the extent invasive species management relates to ESA compliance on Whidbey Island, the BO is expected to ensure compliance with EO 13112. This EIS/OEIS also otherwise satisfies the requirement of EO 13112.
EO 13089, Coral Reef Protection	DoN	EO 13089 preserves and protects the biodiversity, health, heritage, social and economic value of U.S. coral reef ecosystems and the marine environments. All Navy actions that may affect U.S. coral reef ecosystems shall: (a) identify their actions that may affect U.S. coral reef ecosystems; (b) utilize their programs and authorities to protect and enhance the conditions of such ecosystems; and (c) to the extent permitted by law, ensure that any actions they authorize, fund, or carry out will not degrade the conditions of such ecosystems. Navy SOPs ensure all precautions are made to comply with required statutes. No resources that are governed by this EO exist within the NWTRC, therefore, mitigation of effects will not be necessary for the protection of resources under EO 13089.
EO 11990, Protection of Wetlands	DoN	Implementation of the alternatives including the Proposed Action would not have a significant impact on wetlands.
EO 12962, Recreational Fisheries	DoN	EO 12962 requires Federal agencies to fulfill certain duties with regard to promoting the health and access of the public to recreational fishing areas. The alternatives including the Proposed Action comply with EO 12962.

6.1.1 Coastal Zone Management Act Compliance

The CZMA of 1972 (16 United States Code [U.S.C.] Section [§] 1451) encourages coastal States to be proactive in managing coastal zone uses and resources. CZMA established a voluntary coastal planning program; participating States submit a Coastal Management Plan (CMP) to National Oceanographic and Atmospheric Administration (NOAA) for approval. Under CZMA, Federal actions are required to be consistent, to the maximum extent practicable, with the enforceable policies of approved CMPs.

CZMA defines the coastal zone (16 U.S.C. § 1453) as extending, "to the outer limit of State title and ownership under the Submerged Lands Act" (i.e., 3 nautical miles [nm] from the shoreline). The coastal zone extends inland only to the extent necessary to control the shoreline. Excluded from the coastal zone are lands the use of which is by law subject solely to the discretion of, or which is held in trust by, the Federal government (16 U.S.C. § 1453). Accordingly, Federal military lands such as Naval Magazine Indian Island are not within the coastal zone.

The States of Washington, Oregon, and California have approved CMPs. The Washington State's Coastal Zone Management Program of 1976 implements Washington's CZMA program and the Washington State Department of Ecology is the lead coastal management agency. The Oregon Department of Land Conservation and Development (DLCD) is the State's designated coastal management agency and is responsible for reviewing projects for consistency with the CMP and issuing coastal management decisions. The California Coastal Commission, through the *California Coastal Act* (CCA) of 1976 (California Public Resources Code, § 30000 et seq) implements California's CZMA program. In general, these programs include policies to protect and expand public access to shorelines, and to protect, enhance, and restore environmentally sensitive habitats, including intertidal and nearshore waters, wetlands, bays and estuaries, riparian habitat, certain woods and grasslands, streams, lakes, and habitat for rare and endangered plants and animals. Chapter 1, Section 1.6.5 through 1.6.5.3 has a complete discussion of Washington's, Oregon's and California's CZMA programs.

The CZMA federal consistency determination process includes a review of the Proposed Action to determine whether it has reasonably foreseeable effects on coastal zone resources or uses, an in-depth examination of any such effects, and a determination on whether those effects are consistent to the maximum extent practicable with the State's enforceable policies. Under the CZMA, the States of Washington, Oregon, and California must provide an opportunity for public comment and involvement in the Federal coastal consistency determination process.

The Navy will submit its Consistency Determination (CCD) to the States of Washington, Oregon, and California in due course. Its preliminary determination, based in large part on the environmental impact analyses presented in this EIS/OEIS, is that the Navy is consistent to the maximum extent practicable with the State's enforceable CZMA policies.

The EIS/OEIS addresses those coastal resources and uses which would be affected by the Proposed Action, although the impact analyses do not specifically distinguish effects within the coastal zone from those effects outside of it. Public access and recreation are discussed in Sections 3.4 (Water Resources) and 3.16 (Public Health and Safety). Marine resources and biological productivity are discussed in Sections 3.6 (Marine Plants and Invertebrates), 3.7 (Fish), 3.8 (Sea Turtles), 3.9 (Marine Mammals), and 3.10 (Sea Birds). Fishing and commercial and recreational economics is discussed in Sections 3.7 (Fish) and 3.14 (Socioeconomics). Cultural resources are discussed in Section 3.12, Cultural Resources.

6.2 Relationship Between Short-Term Use of Man's Environment and Maintenance and Enhancement of Long-Term Productivity

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

The Proposed Action would result in both short- and long-term environmental effects. However, the Proposed Action would not be expected to result in any impacts that would reduce environmental productivity, permanently narrow the range of beneficial uses of the environment, or pose long-term risks to health, safety or the general welfare of the public. The Navy is committed to sustainable range management, including co-use of the NWTRC with the general public and commercial interests to the extent practicable consistent with accomplishment of the Navy mission and in compliance with applicable law. This commitment to co-use will enhance the long-term productivity of the range areas surrounding the NWTRC.

6.3 Irreversible or Irretrievable Commitment of Resources

NEPA requires that environmental analysis include identification of "any irreversible and irretrievable commitments of resources which would be involved in the Proposed Action should it be implemented." [NEPA Sec. 102 (2)(C)(v), 42 USC § 4332**]**. Irreversible and irretrievable resource commitments are related to the use of non-renewable resources and the effects that the uses of these resources have on future generations. Irreversible effects primarily result from the use or destruction of a specific resource (*e.g.*, energy or minerals) that cannot be replaced within a reasonable time frame. Irretrievable resource commitments involve the loss in value of an affected resource that cannot be restored as a result of the action (*e.g.*, the disturbance of a cultural site). Construction of the shallow water minefield would cause short-term and temporary impacts during construction. Once the minefield is put in place, anchoring points will be carefully chosen by the Navy in order to mitigate any possible effects the laying of the shapes might have on marine resources.

For the alternatives including the Proposed Action, most resource commitments are neither irreversible nor irretrievable. Most impacts are short-term and temporary, or, if long lasting are negligible. This will insure the future management of these resources. No habitat associated with threatened or endangered species would be lost as result of implementation of the Proposed Action. Energy typically associated with construction activities would not be expended and irreversibly lost.

Implementation of the Proposed Action would require fuels used by aircraft, ships, and ground-based vehicles. Since fixed- and rotary-wing flight and ship activities could increase relative, total fuel use would increase. Fuel use by ground-based vehicles involved in training activities would also increase. Therefore, total fuel consumption would increase and this nonrenewable resource would be considered irreversibly lost.

6.4 Energy Requirements and Conservation Potential of Alternatives and Mitigation Measures

Increased training and testing activities associated with both Alternative 1 and Alternative 2 would result in an increase in energy demand over the No Action Alternative. This would result in an increase in fossil fuel consumption, mainly from aircraft, vessels, ground equipment, and power supply. Although the required electricity demands of increased intensity of land-use would be met by the existing electrical generation infrastructure at the NWTRC, the alternatives would result in a net cumulative negative impact on the energy supply.

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

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

Resources that will be permanently and continually consumed by project implementation include water, electricity, natural gas, and fossil fuels; however, the amount and rate of consumption of these resources would not result in significant environmental impacts or the unnecessary, inefficient, or wasteful use of resources. Nuclear powered vessels would be a benefit as it decreases use of fossil fuels.

of natural resources would generally increase with implementation of the alternatives.

Pollution prevention is an important component of mitigation of the alternative’s adverse impacts. To the extent practicable, pollution prevention considerations are included.

Sustainable range management practices are in place that protect and conserve natural and cultural resources; and preservation of access to training areas for current and future training requirements, while addressing potential encroachments that threaten to impact range capabilities.

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5 MITIGATION MEASURES

No References in this section.

6 OTHER CONSIDERATIONS

No References in this section.

7 LIST OF PREPARERS

No References in this section.

9 Distribution List

9 DISTRIBUTION LIST

Following is a list of public officials, government agencies, Native American Tribes and Nations, organizations, and individuals who attended the public scoping meetings, provided comments during the scoping process, or have been identified by the Navy to be on the distribution list for the Northwest Training Range Complex Draft Environmental Impact Statement (DEIS).

Federal and state regulatory agencies and project information repositories (noted below with an asterisk*) will receive both one (1) hard copy version and one (1) CD-ROM version of the Northwest Training Range Complex DEIS. Stakeholders who have specifically requested a hard copy version will also receive one, along with a CD-ROM version. All other stakeholders will receive one (1) CD-ROM version. Additional hard copies and/or CD-ROM versions of the DEIS will be available upon request.

Information Repositories*

Jefferson County Rural Library

Kitsap Regional Library

Oak Harbor Public Library

Timberland Regional Library

Port Townsend Public Library

Lincoln City Public Library

Humboldt County Library

Federal Regulatory Agencies*

Federal Aviation Administration
- Washington D.C. headquarters
- Western Pacific Region Military Liaison

Marine Mammal Commission

National Marine Fisheries Service
- Washington D.C. headquarters
- Northwest Regional Office
- Office of Protected Resources

Olympic Coast National Marine Sanctuary

Pacific Fisheries Management Council

U.S. Army Corps of Engineers
- Northwestern Division

U.S. Coast Guard
- Headquarters NEPA Office
- District 13

U.S. Department of the Interior
- Bureau of Indian Affairs
- Bureau of Land Management
- Environmental Policy & Compliance Department
- Minerals Management Service
- National Park Service, Olympic National Park
- U.S. Fish & Wildlife Service, Pacific Region – Portland Office, Western WA Office
- U.S. Geological Survey, Western Region

U.S. Environmental Protection Agency
- Washington D.C. headquarters
- Region X

U.S. Forest Service
- Pacific Northwest Region

State Regulatory Agencies*

WA State Department of Agriculture

WA State Department of Archaeology & Historic Preservation (SHPO)

WA State Department of Ecology, Environmental Review Section

WA State Department of Fish and Wildlife, Region 6

WA Fish and Wildlife Commission

WA State Department of Natural Resources

WA State Ocean Policy Work Group

WA State Parks and Recreation Commission

Pacific States Marine Fisheries Commission

Puget Sound Partnership

OR Department of Environmental Quality

OR Department of Fish and Wildlife

OR Department of Forestry

OR Department of Land Conservation and Development

OR Department of Parks and Recreation

OR Department of State Lands

OR Military Department

OR Water Resources Department

CA Coastal Commission
- Headquarters
- North Coast District

CA Department of Fish and Game

CA Environmental Protection Agency

CA Resources Agency

Native American Tribes and Nations*

Washington

Hoh Indian Nation

Jamestown S'Klallam Tribe

Lower Elwha Klallam Tribe

Lummi Nation

Makah Tribe

Northwest Indian Fisheries Commission

Point No Point Treaty Council

Port Gamble S'Klallam Tribe

Quileute Tribal Council

Quinalt Indian Nation

Samish Indian Nation

Sauk – Suiattle Tribe

Shoalwater Bay Tribe

Skagit River Cooperative

Skokomish Tribal Nation

Snoqualmie Indian Tribe

Stillaguamish Tribe

Suquamish Tribal Center

Swinomish Indian Tribal Community

Tulalip Tribes of Washington

Upper Skagit Tribe

<u>Oregon</u>

Confederated Tribes of Coos, Lower Umpqua, and Siuslaw Indians

Confederated Tribes of Grande Ronde

Confederated Tribes of Siletz Indians

Confederated Tribes of the Warm Springs Reservation

Coquille Indian

Cow Creek Band of Umpqua Tribe of Indians

Klamath Tribes (Klamath, Modoc, Yahooskin)

<u>California</u>

Tolowa Nation

Trinidad Rancheria

Yurok Indian Reservation

<u>Federal Elected Officials</u>

U.S. Representative
Hon. Jay Inslee, WA District 1

U.S. Representative
Hon. Rick Larsen, WA District 2

U.S. Representative
Hon. Brian Baird, WA
District 3

U.S. Representative
Hon. Cathy Mcmorris
Rodgers, WA District 5

U.S. Representative
Hon. Norm Dicks, WA
District 6

U.S. Representative
Hon. Jim McDermott, WA
District 7

U.S. Representative
Hon. Dave Reichert, WA
District 8

U.S. Representative
Hon. Adam Smith, WA
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U.S. Representative
Hon. Greg Walden, OR
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U.S. Representative
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District 4

U.S. Representative
Hon. Darlene Hooley, OR
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U.S. Senator
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<u>State Elected Officials</u>

Governor of Washington
Hon. Christine Gregoire

Washington State Senator
Hon. Bob Morton, WA
District 7

Washington State Senator
Hon. Mary Margaret Haugen,
WA District 10

Washington State Senator
Hon. Brian Hatfield, WA
District 19

Washington State Senator
Hon. James Hargrove, WA
District 24

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Hon. Dean Takko, WA
District 19, Position 1

Washington State
Representative
Hon. Brian Blake, WA
District 19, Position 2

Washington State
Representative
Hon. Kevin Van De Wege,
WA District 24, Position 1

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Hon. Lynn Kessler, WA
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Oregon State Senator
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District 1

Oregon State Senator
Hon. Joanne Verger, OR
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Oregon State Senator
Hon. David Nelson, OR District 29

Oregon State Representative
Hon. Wayne Krieger, OR District 1

Oregon State Representative
Hon. Arnie Roblan, OR District 9

Oregon State Representative
Hon. Greg Smith, OR District 57

Governor of California
Hon. Arnold Schwarzenegger

California State Senator
Hon. Pat Wiggins, CA District 2

California State Senator
Hon. Sam Aanestad, CA District 4

California State Assemblymember
Hon. Patty Berg, CA District 1

Local Elected Officials

City of Port Townsend
Hon. Michelle Sandoval
Mayor

City of Port Townsend
Hon. Mark Welch
City Councilmember

County of Grays Harbor
Hon. Al Carter
County Commissioner, District 3

Local Agencies

City of Port Townsend
Mr. David Timmons
City Manager

Depoe Bay Nearshore Action Team
Mr. John O'Brien

Others

Olympic Coast National Marine
Sanctuary Advisory Council

Individuals

Doug Acmmon
Aberdeen, WA

Gordon Anderson
Arcata, CA

Dr. David Bain
Friday Harbor, WA

Ben Baumgart
Ocean Shores, WA

Ken and Jenee Bearden
Aberdeen, WA

Peggy V. Beck
Port Angeles, WA

Paul Boring
Oak Harbor, WA

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Aberdeen, WA

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Depoe Bay, OR

Stephanie Buffum Field
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Beach, WA

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Peggy Willis
Seattle, WA

Appendix A

Notice of Intent

DEPARTMENT OF DEFENSE

Department of the Navy

Notice of Intent To Prepare an Environmental Impact Statement/ Overseas Environmental Impact Statement for Navy Training Operations in the Northwest Training Range Complex and Notice of Public Scoping Meetings

AGENCY: Department of the Navy, DoD.

ACTION: Notice.

SUMMARY: Pursuant to section 102(2)(c) of the National Environmental Policy Act (NEPA) of 1969, as implemented by the Council on Environmental Quality Regulations (40 CFR Parts 1500–1508), and Executive Order 12114, the Department of the Navy (Navy) announces its intent to prepare an Environmental Impact Statement (EIS)/ Overseas EIS to evaluate the potential environmental effects of maintaining Fleet readiness through the use of the Northwest Training Range Complex (NWTRC) to support current, emerging, and future training activities. The proposed action serves to implement range enhancements to upgrade and modernize range capabilities within the NWTRC thereby ensuring critical Fleet requirements are met. The Navy will invite the U.S. Fish and Wildlife Service and National Marine Fisheries Service to be cooperating agencies in preparation of this EIS/OEIS.

DATES AND ADDRESSES: Five public scoping meetings will be held in Washington, Oregon and California to receive oral and written comments on environmental concerns that should be addressed in the EIS/OEIS. Public scoping meetings will be held at the following dates, times and locations: September 10, 2007, from 6 p.m. to 9 p.m. at Coachman Inn, 32959 State Route 20, Oak Harbor, Washington, September 11, 2007, from 6 p.m. to 9 p.m., at Pacific Beach Fire Hall, 4586 State Route 109, Pacific Beach, Washington, September 12, 2007, from 6 p.m. to 9 p.m., at Grays Harbor College Cafeteria, 1620 Edward P. Smith Drive, Aberdeen, Washington, September 13, 2007, from 6 p.m. to 9 p.m., at Spouting Horn Restaurant, 110 Southeast Highway 101, Depoe Bay, Oregon, and September 15, 2007, from 6 p.m. to 9 p.m., at Eureka's Women's Club, 1531 J Street, Eureka, California.

Each of the five scoping meetings will consist of an informal, open house session with information stations staffed by Navy representatives. Details of the meeting locations and time will be announced in local newspapers. Additional information concerning meeting times will be available on the EIS/OEIS web page located at: *http://www.NWTRangeComplexEIS.com.*

FOR FURTHER INFORMATION CONTACT: Kimberly Kler, Naval Facilities Engineering Command, Northwest, Attention: NWTRC EIS/OEIS, 1101 Tautog Circle Suite 203, Silverdale, Washington, 98315–1101.

SUPPLEMENTARY INFORMATION: The NWTRC consists of airspace, surface operating areas, and land range facilities in the Pacific Northwest. Components of the NWTRC encompass 126,630 nm^2 of surface/subsurface ocean operating area, 33,997 nm^2 of special use airspace, and 22 nm^2 of restricted airspace. The EIS/ OEIS study area lies within the NWTRC, and encompasses surface and subsurface ocean operating areas, land training areas and special use airspace in Washington, and over-ocean special use airspace offshore of Washington, Oregon and northern California. These ranges and operating areas are used to conduct training involving military hardware, personnel, tactics, munitions, explosives, and electronic combat systems. The NWTRC serves as a backyard range for those units homeported in the Pacific Northwest area including those aviation, surface ship, submarine, and Explosive Ordnance Disposal units homeported at Naval Air Station Whidbey Island, Naval Station Everett, Naval Base Kitsap—Bremerton, Naval Base Kitsap—Bangor, and Puget Sound Naval Shipyard.

The purpose of the Proposed Action is to: (1) Achieve and maintain Fleet readiness using the NWTRC to support and conduct current, emerging, and future training activities and research, development, test, and evaluation (RDT&E) events (primarily unmanned aerial vehicles); (2) expand warfare missions supported by the NWTRC, consistent with the requirements of the Fleet Readiness Training Plan (FRTP) and other transformation initiatives; and (3) upgrade and modernize existing range capabilities to enhance and sustain Navy training and RDT&E.

The need for the Proposed Action is to: (1) Maintain current levels of military readiness by training in the NWTRC; (2) accommodate future increases in operational training tempo in the NWTRC and support the rapid deployment of naval units or strike groups; (3) achieve and sustain readiness of ships, submarines, and aviation squadrons using the NWTRC so that they can quickly surge significant combat power in the event of a national crisis or contingency operation and consistent with the FRTP; (4) support the acquisition and implementation of advance military technology into the Fleet; (5) identify shortfalls in range capabilities, particularly training infrastructure and instrumentation, and address through range investments and enhancements; and (6) maintain the long-term viability of the NWTRC while protecting human health and the environment and enhancing the quality and communication capability and safety of the range complex.

The No Action Alternative is the continuation of training and RDT&E. Alternative 1 consists of an increase in the number of training activities from baseline levels and force structure changes associated with the introduction of new weapon systems, vessels, and aircraft into the Fleet. Alternative 2 consists of all elements of Alternative 1. In addition, Alternative 2 includes an increase in the number of training activities over Alternative 1 levels and implementation of range enhancements.

Environmental issues that will be addressed in the EIS/OEIS, as applicable, include but are not limited to: air quality; airspace; biological resources, including threatened and endangered species; cultural resources; geology and soils; hazardous materials and waste; health and safety; land use; noise; socioeconomics; transportation; and water resources.

The Navy is initiating the scoping process to identify community concerns and local issues that will be addressed in the EIS/OEIS. Federal agencies, state agencies, and local agencies, Native American Indian Tribes and Nations, the public, and interested persons are encouraged to provide oral and/or written comments to the Navy to identify specific issues or topics of environmental concern that the commenter believes the Navy should consider. All comments, written or provided orally at the scoping meetings, will receive the same consideration during EIS/OEIS preparation. Written comments must be postmarked no later than September 29, 2007, and should be mailed to: Naval Facilities Engineering Command, Northwest, 1101 Tautog Circle, Suite 203, Silverdale, Washington, 98315–1101, Attention: Ms. Kimberly Kler—NWTRC EIS/OEIS.

Dated: July 25, 2007.

M.C. Holley,

Lieutenant Commander, Office of the Judge Advocate General, U.S. Navy, Administrative Law Division, Alternate Federal Register Liaison Officer.

[FR Doc. E7–14784 Filed 7–30–07; 8:45 am]

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Appendix B

Cooperating Agency Correspondence

DEPARTMENT OF THE NAVY
OFFICE OF THE CHIEF OF NAVAL OPERATIONS
2000 NAVY PENTAGON
WASHINGTON, DC 20350-2000

IN REPLY REFER TO

5090
Ser N456E/7U158218
2 Aug 2007

Dr. William T. Hogarth
Assistant Administrator
National Oceanic and Atmospheric
Administration (NOAA) Fisheries
1315 East West Highway
Silver Spring, MD 20910

Dear Dr. Hogarth:

In accordance with the National Environmental Policy Act (NEPA) and Executive Order 12114, the Department of the Navy (Navy) is initiating the preparation of an Environmental Impact Statement/ Overseas Environmental Impact Statement (EIS/OEIS) to evaluate potential environmental effects of using the Northwest Training Range Complex (NWTRC) to achieve and maintain Fleet readiness and to support and conduct current, emerging, and future training activities and research, development, test, and evaluation (RDT&E) events.

In order to adequately evaluate the potential environmental effects of the Proposed Action, Navy and the National Marine Fisheries Service would need to work together on acoustic effects to marine species protected under the Marine Mammal Protection Act (MMPA) and the Endangered Species Act. To assist in this effort and in accordance with 40 CFR Part 1501 and the Council on Environmental Quality Cooperating Agency guidance issued on January 30, 2002, Navy requests NMFS serve as a cooperating agency for the development of the NWTRC EIS/OEIS.

The Proposed Action for the Navy NWTRC EIS/OEIS is to:

- Maintain baseline operations at current levels;
- Increase training operations from current levels as necessary to support the Fleet Readiness Training Plan;
- Accommodate mission requirements associated with force structure change;
- Implement enhanced range complex capabilities;

- Increase and accommodate planned RDT&E events (primarily Unmanned Aerial Vehicles).

The Proposed Action will further our statutory obligations under Title 10 of the United States Code governing the roles and responsibilities of the Navy.

The No Action Alternative is the continuation of training activities and major range events in the NWTRC at the current level. Two action alternatives are proposed to accomplish the Proposed Action. Alternative 1 consists of an increase in the number of training activities, from levels described in the No Action Alternative, along with force structure changes associated with the introduction of new weapon systems, vessels, and aircraft into the Fleet. Alternative 2 consists of all elements of Alternative 1 with an increase in the number of training activities and implementation of range enhancements.

The EIS/OEIS will address measurably foreseeable activities in the particular geographical areas affected by the No-Action Alternative and action alternatives. This EIS/OEIS will analyze the effects of sound in the water on marine mammals in the areas where NWTRC activities occur. In addition, other environmental resource areas that will be addressed applicable in the EIS/OEIS include: air quality; airspace; biological resources, including threatened and endangered species; cultural resources; geology and soils; hazardous materials and waste; health and safety; land use; noise; socioeconomics; transportation; and water resources.

As the lead agency, the Navy will be responsible for overseeing preparation of the EIS/OEIS that includes but is not limited to the following:

- Gathering all necessary background information and preparing the EIS/OEIS and all necessary permit application associated with acoustic issues on the underwater ranges.

- Working with NMFS personnel to determine the method of estimating potential effects to protected marine species, including threatened and endangered species.

- Determining the scope of the IES/OEIS, including the alternatives evaluated.

- Circulating the appropriate NEPA documentation to the general public and any other interested parties.

- Scheduling and supervising meetings held in support of the NEPA process, and compiling any comments received.

- Maintaining an administrative record and responding to any Freedom of Information Act requests relating to the EIS/OEIS.

As a cooperating agency, the Navy requests NMFS support the Navy in the following manner:

- Provide timely comments after the Agency Information Meeting (which will be held at the onset of the EIS/OEIS process) and on working drafts of the EIS/OEIS documents. The Navy requests that comments on draft EIS/OEIS documents be provided within 21 calendar days.

- Respond to Navy requests for information. Timely NMFS input will be critical to ensure a successful NEPA process.

- Coordinate, to the maximum extent practicable, any public comment periods that is necessary in the MMPA permitting process with the Navy's NEPA public comment periods.

- Participate, as necessary, in meetings hosted by the Navy for discussion of EIS/OEIS related issues.

- Adhere to the overall project schedule as agreed upon by the Navy and NMFS.

- Provide a formal, written response to this request.

The Navy views this agreement as important to the successful completion of the NEPA process for the Northwest Training Range Complex EIS/OEIS. It is Navy's goal to complete the analysis as expeditiously as possible, while using the best scientific information available. NMFS assistance will be invaluable in this endeavor.

My point of contact for this action is Ms. Karen M. Foskey, (703) 602-2859, email:Karen.Foskey@navy.mil.

Sincerely,

William G. Mattheis

WILLIAM G. MATTHEIS
Acting Director, Environmental
Readiness Division (OPNAV N45)

Copy to:
Deputy Assistant Secretary of the Navy (Environment)
Office of Assistant General Counsel (Installation & Environment)
Commander, U.S. Fleet Forces Command (N73, N77)
Commander, U.S. Pacific Fleet (N01CE, N7)
Commander, Naval Installations Command (N45)
Commander, Navy Region Northwest (N40)
Commander, Navy Region Southwest (N40)

DEPARTMENT OF THE NAVY
COMMANDER
UNITED STATES PACIFIC FLEET
250 MAKALAPA DRIVE
PEARL HARBOR, HAWAII 96860-3131

IN REPLY REFER TO:
5090
N01CEB/0692
9 Aug 07

Ren Lohoefener
Regional Director
U.S. Fish & Wildlife Service – Pacific Region
911 NE 11th Ave
Portland, OR 97232

Dear Mr. Lohoefener:

In accordance with the National Environmental Policy Act (NEPA), the Department of the Navy (Navy) is initiating the preparation of an Environmental Impact Statement (EIS)/Overseas EIS (OEIS) to support decisions by the Navy concerning the Proposed Action to increase usage and to enhance capability of the Northwest Training Range Complex (NWTRC). In order to adequately evaluate the potential environmental effects of the Proposed Action on threatened and endangered species, the Navy is requesting, in accordance with 40 CFR Part 1501 and the Council on Environmental Quality Cooperating Agency guidance issued on January 30, 2002, that U.S. Fish & Wildlife Service serve as a cooperating agency for the development of the EIS/OEIS.

The No Action Alternative is the continuation of training activities and major range events in the NWTRC. Two action alternatives are proposed to accomplish the Proposed Action. Alternative 1 consists of an increase in the number of training activities from levels described in the No Action Alternative, along with force structure changes associated with the introduction of new weapon systems, vessels, and aircraft into the Fleet. Alternative 2 consists of all elements of Alternative 1 with an increase in the number of training activities and implementation of range enhancements.

The purpose of the proposed action is to:

- Achieve and maintain Fleet readiness using the NWTRC to support and conduct current, emerging, and future training activities and research, development, test, and evaluation (RDT&E) events (primarily Unmanned Aerial Vehicles);

- Expand Warfare Missions supported by the NWTRC, consistent with the requirements of the Fleet Readiness Training Plan (FRTP) and other transformation initiatives; and

- Upgrade/modernize existing range capabilities to enhance and sustain Navy training and RDT&E events.

The EIS/OEIS will address measurably foreseeable activities in the particular geographical areas affected by the No-Action Alternative and action alternatives. The EIS/OEIS will also analyze the potential impacts of additional training missions. This EIS/OEIS will analyze the effects of sound in the water on marine mammals in the areas where NWTRC activities occur. In addition, other environmental resource areas that will be addressed as applicable in the EIS/OEIS include but not limited to: air quality; airspace; biological resources, including threatened and endangered species; cultural resources; geology and soils; hazardous materials and waste; health and safety; land use; noise; socioeconomics; transportation; and water resources.

As the lead agency, the Navy will be responsible for overseeing preparation of the EIS/OEIS that includes but is not limited to the following:

- Gathering all necessary background information and preparing the EIS/OEIS.

- Working with U.S. Fish & Wildlife Service personnel to evaluate potential impacts of changes and enhancements on wildlife refuges, critical habitat, and wildlife resources including threatened and endangered species.

- Determining the scope of the EIS/OEIS, including the alternatives evaluated.

- Circulating the appropriate NEPA documentation to the general public and any other interested parties.

- Scheduling and supervising meetings held in support of the NEPA process, and compiling any comments received.

- Maintaining an administrative record and responding to any Freedom of Information Act requests relating to the EIS/OEIS.

As a cooperating agency, the Navy requests the U.S. Fish & Wildlife Service support the Navy in the following manner:

- Providing timely comments throughout the EIS process, to include, on working drafts of the EIS/OEIS documents. The Navy requests that comments on draft EIS/OEIS documents be provided within 30 calendar days.

- Responding to Navy requests for information. Timely U.S. Fish & Wildlife Service input will be critical to ensure a successful NEPA process.

- Participating, as necessary, in meetings hosted by the Navy for discussion of EIS/OEIS related issues.

- Adhering to the overall schedule as set forth by the Navy.

- Providing a formal, written response to this request.

My point of contact for this is Carolyn L. Winters, (360) 315-5092 or at Email: carolyn.winters@navy.mil.

Sincerely,

J. P. RIOS
Captain, U.S. Navy
Deputy Fleet Civil Engineer
By direction

Copy to:
Chief of Naval Operations (N45)
Commander, U.S. Fleet Forces Command (N73, N77)
Commander, U.S. Pacific Fleet (N7)
Commander, Naval Installations Command (N45)
Commander, Navy Region Northwest (N40)
Commander, Navy Region Southwest (N40)
Commander, Naval Facilities Engineering Command, Northwest (N45)
Commander, Naval Facilities Engineering Command, Soqthwest (N45)

UNITED STATES DEPARTMENT OF COMMERCE
National Oceanic and Atmospheric Administration
NATIONAL MARINE FISHERIES SERVICE
1315 East-West Highway
Silver Spring, Maryland 20910

THE DIRECTOR

SEP : / 2007

William G. Mattheis
Acting Director, Environmental Readiness Division
Department of the Navy
2000 Navy Pentagon
Washington, DC 20350-2000

Dear Mr. Mattheis:

Thank you for your letter requesting that NOAA's National Marine Fisheries Service (NMFS) be a cooperating agency in the preparation of an Environmental Impact Statement (EIS) to evaluate potential environmental effects of using the Department of the Navy's Northwest Training Range Complex to achieve and maintain military readiness and to support and conduct training activities and research, development, test, and evaluation events.

We support the Navy's decision to prepare an EIS on these activities and agree to be a cooperating agency, due, in part, to our responsibilities under section 101(a)(5)(A) of the Marine Mammal Protection Act and section 7 of the Endangered Species Act. As agreed upon with Navy staff, NMFS staff will provide comments on draft EISs to the Navy within 28 days of receipt of the document. Otherwise, NMFS will make every effort to support the Navy in the specific ways described in your letter.

If you need any additional information, please contact Ms. Jolie Harrison at (301) 713-2289, ext. 166.

Sincerely,

William T. Hogarth, Ph.D.

THE ASSISTANT ADMINISTRATOR
FOR FISHERIES

Appendix C

Air Emissions Calculations

Table C-1. Surface Ship Air Emissions—No Action Alternative

Scenario	Type Training	Number of Ships	Program Totals	Nomenclature	Ship/Boat Type	Vessel Mode	Ship Time on Range (hrs)	Percent at Each Power Level	Total Time on Range (hrs)	Percentage 0-3 nm from shore	Percentage 3-12 nm from Shore	Percentage >12 nm from Shore	Total Time 0-3 nm from shore	Total Time 3-12 nm from shore	Total Time >12 nm from shore	Emissions Factors (lb/hr)					Emissions: Emissions 0-3 nm Offshore (lbs)					Emissions 3-12 nm Offshore - US Territory (lbs)					Emissions >12 nm Offshore - Outside US Territory				
							Hours	%	Hours	Percent			Hours			CO	NOx	HC	SOx	PM10	CO	Nox	HC	Sox	PM	CO	Nox	HC	Sox	PM	CO	Nox	HC	Sox	PM
Training Exercises																																			
1	Air Combat Maneuvers	0																																	
2	A-A Missiles	0																																	
3	S-A Gunnery Exercise	17		DDG	Guided Missile Destroyer	DDG-2	3.0	100%	51.0	0%	0%	100%	0.0	0.0	51.0	103.99	48.9	8.0	17.9	2.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	5303.5	2493.9	409.5	914.9	125.5
		51		FFG	Guided Missile Frigate	FFG-2	3.0	100%	153.0	0%	0%	100%	0.0	0.0	153.0	66.82	67.7	7.8	11.6	3.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	10223.5	10361.2	1194.9	1770.2	497.3
		4		AOE	Logistics/Support	AOE-1	3.0	100%	12.0	0%	0%	100%	0.0	0.0	12.0	3.73	22.0	2.8	66.1	13.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	44.8	263.9	33.5	793.7	159.4
4	S-A Missiles	0		CVN	Nuclear Carrier (No emissions)		4.0			0%	0%	100%	0.0	0.0	0.0																				
5	S-S GUNEX	4		CVN	Nuclear Carrier (No emissions)		2.0	100%	8.0	0%	0%	100%	0.0	0.0	8.0																				
		23		DDG	Guided Missile Destroyer	DDG-1	2.0	100%	46.0	0%	0%	100%	0.0	0.0	46.0	102.98	47.3	8.1	17.0	2.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	4737.1	2177.6	372.6	783.8	108.1
		70		FFG	Guided Missile Frigate	FFG-1	2.0	100%	140.0	0%	0%	100%	0.0	0.0	140.0	65.75	66.4	7.9	10.9	3.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	9205.0	9289.0	1104.6	1524.6	439.6
		2		AOE	Logistics/Support	AOE-1	2.0	100%	4.0	0%	0%	100%	0.0	0.0	4.0	3.73	22.0	2.8	66.1	13.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	14.9	88.0	11.2	264.6	53.1
6	A-S BOMBEX	0																																	
7	SINKEX	2		CG	Cruiser	CG-2	8.0	100%	16.0	0%	0%	100%	0.0	0.0	16.0	107.78	47.1	8.8	21.0	2.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1724.5	753.9	141.1	336.3	42.1
		4		DDG	Guided Missile Destroyer	DDG-2	8.0	100%	32.0	0%	0%	100%	0.0	0.0	32.0	103.99	48.9	8.0	17.9	2.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	3327.7	1564.8	257.0	574.1	78.7
		2		FFG	Guided Missile Frigate	FFG-2	8.0	100%	16.0	0%	0%	100%	0.0	0.0	16.0	66.82	67.7	7.8	11.6	3.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1069.1	1083.5	125.0	185.1	52.0
		1		SSN	Submarines (No emissions)		8.0	100%	8.0	0%	0%	100%	0.0	0.0	8.0																				
8	MPA ASW TRACKEX	32		SSN	Submarines (No emissions)		8.0	100%	256.0	0%	0%	100%	0.0	0.0	256.0																				
9	EER/IEER ASW																																		
10	Surface Ship ASW TRACKEX	24		DDG	Guided Missile Destroyer	DDG-3	36.0	100%	864.0	1%	2%	97%	8.6	17.3	838.1	106.67	53.8	7.8	21.2	2.8	921.6	465.2	67.7	183.3	24.2	1843.3	930.4	135.5	366.7	48.4	89398.0	45122.2	6570.5	17784.1	2346.6
		36		FFG	Guided Missile Frigate	FFG-3	36.0	100%	1296.0	1%	2%	97%	13.0	25.9	1257.1	120.04	78.1	11.6	16.1	4.3	1555.7	1012.3	150.9	208.4	55.7	3111.4	2024.6	301.7	416.8	111.5	150904.7	98193.6	14632.9	20214.5	5405.6
11	Sub ASW Trackex	64		SSBN	Submarines (No emissions)																														
		32		SSGN	Submarines (No emissions)																														
12	Elec Combat	0		CVN	Nuclear Carrier (No emissions)		2.0	100%	0.0	0%	50%	50%																							
		0		DDG	Guided Missile Destroyer	DDG-2	2.0	100%	0.0	0%	50%	50%	0.0	0.0	0.0	103.99	48.9	8.0	17.9	2.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
		0		FFG	Guided Missile Frigate	FFG-2	2.0	100%	0.0	0%	50%	50%	0.0	0.0	0.0	66.82	67.7	7.8	11.6	3.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
		0		AOE	Logistics/Support	AOE-1	2.0	100%	0.0	0%	50%	50%	0.0	0.0	0.0	3.73	22.0	2.8	66.1	13.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
		0		SSBN	Submarines (No emissions)		2.0	100%	0.0	0%	50%	50%																							
		0		SSGN	Submarines (No emissions)		2.0	100%	0.0	0%	50%	50%																							
13	Mine Countermeasures	58		RHIB	Rigid Hull Inflatable Boat	RIB-4	5.0	100%	290.0	100%	0%	0%	290.0	0.0	0.0	0.34	9.1	0.1	1.4	0.2	98.6	2650.6	17.4	417.6	43.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
14	Land Demolition Training																																		
15	Insertion/Extraction	0																																	
16	NSW Training	35		RHIB	Rigid Hull Inflatable Boat	RIB-4	6.0	100%	210.0	100%	0%	0%	210.0	0.0	0.0	0.34	9.1	0.1	1.4	0.2	71.4	1919.4	12.6	302.4	31.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
		70		SDB	Seal Delivery Vehicle																														
17	HARMEX	0																																	
18	ISR	0																																	
19	UAV	0																																	
	Total	426														**Total Emissions tons**					**1.32**	**3.02**	**0.12**	**0.56**	**0.08**	**2.48**	**1.48**	**0.22**	**0.39**	**0.08**	**137.98**	**85.70**	**12.43**	**22.57**	**4.65**
																Total Emissions within US Territory					**3.80**	**4.50**	**0.34**	**0.95**	**0.16**										

Table C-2. Surface Ship Air Emissions—Alternative 1

Scenario	Type Training	Number of Ships	Program Totals	Nomenclature	Ship/Boat Type	Vessel Mode	Ship Time on Range (hrs)	Percent at Each Power Level	Total Time on Range (hrs)	Percentage 0-3 nm from shore	Percentage 3-12 nm from Shore	Percentage >12 nm from Shore	Total Time 0-3 nm from shore	Total Time 3-12 nm from shore	Total Time >12 nm from shore	Emissions Factors (lb/hr)					Emissions Emissions 0-3 nm Offshore (lbs)					Emissions 3-12 nm Offshore - US Territory (lbs)					Emissions >12 nm Offshore - Outside US Territory				
							Hours	%	Hours	Percent			Hours			CO	NOx	HC	SOx	PM10	CO	Nox	HC	Sox	PM	CO	Nox	HC	Sox	PM	CO	Nox	HC	Sox	PM
Training Exercises																																			
1	Air Combat Maneuvers	0																																	
2	A-A Missiles	0																																	
3	S-A Gunnery Exercise	19		DDG	Guided Missile Destroyer	DDG-2	3.0	100%	57.0	0%	0%	100%	0.0	0.0	57.0	103.99	48.9	8.0	17.9	2.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	5927.4	2787.3	457.7	1022.6	140.2
		57		FFG	Guided Missile Frigate	FFG-2	3.0	100%	171.0	0%	0%	100%	0.0	0.0	171.0	66.82	67.7	7.8	11.6	3.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	11426.2	11580.1	1335.5	1978.5	555.8
		4		AOE	Logistics/Support	AOE-1	3.0	100%	12.0	0%	0%	100%	0.0	0.0	12.0	3.73	22.0	2.8	66.1	13.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	44.8	263.9	33.5	793.7	159.4
4	S-A Missiles	0		CVN	Nuclear Carrier (No emissions)		4.0			0%	0%	100%	0.0	0.0	0.0																				
5	S-S GUNEX	4		CVN	Nuclear Carrier (No emissions)		2.0	100%	8.0	0%	0%	100%	0.0	0.0	8.0																				
		21		DDG	Guided Missile Destroyer	DDG-1	2.0	100%	42.0	0%	0%	100%	0.0	0.0	42.0	102.98	47.3	8.1	17.0	2.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	4325.2	1988.3	340.2	715.7	98.7
		63		FFG	Guided Missile Frigate	FFG-1	2.0	100%	126.0	0%	0%	100%	0.0	0.0	126.0	65.75	66.4	7.9	10.9	3.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	8284.5	8360.1	994.1	1372.1	395.6
		2		AOE	Logistics/Support	AOE-1	2.0	100%	4.0	0%	0%	100%	0.0	0.0	4.0	3.73	22.0	2.8	66.1	13.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	14.9	88.0	11.2	264.6	53.1
6	A-S BOMBEX	0																																	
7	SINKEX	4		CG	Cruiser	CG-2	8.0	100%	32.0	0%	0%	100%	0.0	0.0	32.0	107.78	47.1	8.8	21.0	2.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	3449.0	1507.8	282.2	672.6	84.2
		8		DDG	Guided Missile Destroyer	DDG-2	8.0	100%	64.0	0%	0%	100%	0.0	0.0	64.0	103.99	48.9	8.0	17.9	2.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	6655.4	3129.6	513.9	1148.2	157.4
		4		FFG	Guided Missile Frigate	FFG-2	8.0	100%	32.0	0%	0%	100%	0.0	0.0	32.0	66.82	67.7	7.8	11.6	3.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	2138.2	2167.0	249.9	370.2	104.0
		2		SSN	Submarines (No emissions)		8.0	100%	16.0	0%	0%	100%	0.0	0.0	16.0																				
8	MPA ASW TRACKEX	33		SSN	Submarines (No emissions)		8.0	100%	264.0	0%	0%	100%	0.0	0.0	264.0																				
9	EER/IEER ASW																																		
10	Surface Ship ASW TRACKEX	26		DDG	Guided Missile Destroyer	DDG-3	36.0	100%	936.0	1%	2%	97%	9.4	18.7	907.9	106.67	53.8	7.8	21.2	2.8	998.4	503.9	73.4	198.6	26.2	1996.9	1007.9	146.8	397.2	52.4	96847.8	48882.4	7118.1	19266.1	2542.2
		39		FFG	Guided Missile Frigate	FFG-3	36.0	100%	1404.0	1%	2%	97%	14.0	28.1	1361.9	120.04	78.1	11.6	16.1	4.3	1685.4	1096.7	163.4	225.8	60.4	3370.7	2193.3	326.9	451.5	120.7	163480.1	106376.4	15852.3	21899.0	5856.1
11	Sub ASW Trackex	67		SSBN	Submarines (No emissions)																														
		33		SSGN	Submarines (No emissions)																														
12	Elec Combat	0		CVN	Nuclear Carrier (No emissions)		2.0	100%	0.0	0%	50%	50%																							
		0		DDG	Guided Missile Destroyer	DDG-2	2.0	100%	0.0	0%	50%	50%	0.0	0.0	0.0	103.99	48.9	8.0	17.9	2.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
		0		FFG	Guided Missile Frigate	FFG-2	2.0	100%	0.0	0%	50%	50%	0.0	0.0	0.0	66.82	67.7	7.8	11.6	3.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
		0		AOE	Logistics/Support	AOE-1	2.0	100%	0.0	0%	50%	50%	0.0	0.0	0.0	3.73	22.0	2.8	66.1	13.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
		0		SSBN	Submarines (No emissions)		2.0	100%	0.0	0%	50%	50%																							
		0		SSGN	Submarines (No emissions)		2.0	100%	0.0	0%	50%	50%																							
13	Mine Countermeasures	68		RHIB	Rigid Hull Inflatable Boat	RIB-4	5.0	100%	340.0	100%	0%	0%	340.0	0.0	0.0	0.34	9.1	0.1	1.4	0.2	115.6	3107.6	20.4	489.6	51.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
14	Land Demolition Training																																		
15	Insertion/Extraction	0																																	
16	NSW Training	35		RHIB	Rigid Hull Inflatable Boat	RIB-4	6.0	100%	210.0	100%	0%	0%	210.0	0.0	0.0	0.34	9.1	0.1	1.4	0.2	71.4	1919.4	12.6	302.4	31.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
		70		SDB	Seal Delivery Vehicle																														
17	HARMEX	0																																	
18	ISR	0																																	
19	UAV	0																																	
	Total	454														**Total Emissions tons**					**1.44**	**3.31**	**0.13**	**0.61**	**0.08**	**2.68**	**1.60**	**0.24**	**0.42**	**0.09**	**151.30**	**93.57**	**13.59**	**24.75**	**5.07**
																Total Emissions within US Territory					**4.12**	**4.91**	**0.37**	**1.03**	**0.17**										

Table C-3. Surface Ship Air Emissions—Alternative 2

Scenario	Type Training	Number of Ships	Program Totals	Nomenclature	Ship/Boat Type	Vessel Mode	Ship Time on Range (hrs)	Percent at Each Power Level	Total Time on Range (hrs)	Percentage 0-3 nm from shore	Percentage 3-12 nm from Shore	Percentage >12 nm from Shore	Total Time 0-3 nm from shore	Total Time 3-12 nm from shore	Total Time >12 nm from shore	Emissions Factors (lb/hr)					Emissions — Emissions 0-3 nm Offshore (lbs)					Emissions 3-12 nm Offshore - US Territory (lbs)					Emissions >12 nm Offshore - Outside US Territory				
							Hours	%	Hours	Percent			Hours			CO	NOx	HC	SOx	PM10	CO	Nox	HC	Sox	PM	CO	Nox	HC	Sox	PM	CO	Nox	HC	Sox	PM
Training Exercises																																			
1	Air Combat Maneuvers	0																																	
2	A-A Missiles	0																																	
3	S-A Gunnery Exercise	38		DDG	Guided Missile Destroyer	DDG-2	3.0	100%	114.0	0%	0%	100%	0.0	0.0	114.0	103.99	48.9	8.0	17.9	2.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	11854.9	5574.6	915.4	2045.2	280.4
		113		FFG	Guided Missile Frigate	FFG-2	3.0	100%	339.0	0%	0%	100%	0.0	0.0	339.0	66.82	67.7	7.8	11.6	3.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	22652.0	22957.1	2647.6	3922.2	1101.8
		9		AOE	Logistics/Support	AOE-1	3.0	100%	27.0	0%	0%	100%	0.0	0.0	27.0	3.73	22.0	2.8	66.1	13.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	100.7	593.7	75.3	1785.8	358.6
4	S-A Missiles	0		CVN	Nuclear Carrier (No emissions)		4.0			0%	0%	100%	0.0	0.0	0.0																				
5	S-S GUNEX	9		CVN	Nuclear Carrier (No emissions)		2.0	100%	18.0	0%	0%	100%	0.0	0.0	18.0																				
		42		DDG	Guided Missile Destroyer	DDG-1	2.0	100%	84.0	0%	0%	100%	0.0	0.0	84.0	102.98	47.3	8.1	17.0	2.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	8650.3	3976.6	680.4	1431.4	197.4
		126		FFG	Guided Missile Frigate	FFG-1	2.0	100%	252.0	0%	0%	100%	0.0	0.0	252.0	65.75	66.4	7.9	10.9	3.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	16569.0	16720.2	1988.3	2744.3	791.3
		4		AOE	Logistics/Support	AOE-1	2.0	100%	8.0	0%	0%	100%	0.0	0.0	8.0	3.73	22.0	2.8	66.1	13.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	29.8	175.9	22.3	529.1	106.2
6	A-S BOMBEX	0																																	
7	SINKEX	4		CG	Cruiser	CG-2	8.0	100%	32.0	0%	0%	100%	0.0	0.0	32.0	107.78	47.1	8.8	21.0	2.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	3449.0	1507.8	282.2	672.6	84.2
		8		DDG	Guided Missile Destroyer	DDG-2	8.0	100%	64.0	0%	0%	100%	0.0	0.0	64.0	103.99	48.9	8.0	17.9	2.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	6655.4	3129.6	513.9	1148.2	157.4
		4		FFG	Guided Missile Frigate	FFG-2	8.0	100%	32.0	0%	0%	100%	0.0	0.0	32.0	66.82	67.7	7.8	11.6	3.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	2138.2	2167.0	249.9	370.2	104.0
		2		SSN	Submarines (No emissions)		8.0	100%	16.0	0%	0%	100%	0.0	0.0	16.0																				
8	MPA ASW TRACKEX	34		SSN	Submarines (No emissions)		8.0	100%	272.0	0%	0%	100%	0.0	0.0	272.0																				
9	EER/IEER ASW																																		
10	Surface Ship ASW TRACKEX	26		DDG	Guided Missile Destroyer	DDG-3	36.0	100%	936.0	1%	2%	97%	9.4	18.7	907.9	106.67	53.8	7.8	21.2	2.8	998.4	503.9	73.4	198.6	26.2	1996.9	1007.9	146.8	397.2	52.4	96847.8	48882.4	7118.1	19266.1	2542.2
		39		FFG	Guided Missile Frigate	FFG-3	36.0	100%	1404.0	1%	2%	97%	14.0	28.1	1361.9	120.04	78.1	11.6	16.1	4.3	1685.4	1096.7	163.4	225.8	60.4	3370.7	2193.3	326.9	451.5	120.7	163480.1	106376.4	15852.3	21899.0	5856.1
11	Sub ASW Trackex	67		SSBN	Submarines (No emissions)																														
		33		SSGN	Submarines (No emissions)																														
12	Elec Combat	50		CVN	Nuclear Carrier (No emissions)		2.0	100%	100.0	0%	50%	50%																							
		50		DDG	Guided Missile Destroyer	DDG-2	2.0	100%	100.0	0%	50%	50%	0.0	50.0	50.0	103.99	48.9	8.0	17.9	2.5	0.0	0.0	0.0	0.0	0.0	5199.5	2445.0	401.5	897.0	123.0	5199.5	2445.0	401.5	897.0	123.0
		100		FFG	Guided Missile Frigate	FFG-2	2.0	100%	200.0	0%	50%	50%	0.0	100.0	100.0	66.82	67.7	7.8	11.6	3.3	0.0	0.0	0.0	0.0	0.0	6682.0	6772.0	781.0	1157.0	325.0	6682.0	6772.0	781.0	1157.0	325.0
		25		AOE	Logistics/Support	AOE-1	2.0	100%	50.0	0%	50%	50%	0.0	25.0	25.0	3.73	22.0	2.8	66.1	13.3	0.0	0.0	0.0	0.0	0.0	93.3	549.8	69.8	1653.5	332.0	93.3	549.8	69.8	1653.5	332.0
		25		SSBN	Submarines (No emissions)		2.0	100%	50.0	0%	50%	50%																							
		25		SSGN	Submarines (No emissions)		2.0	100%	50.0	0%	50%	50%																							
13	Mine Countermeasures	68		RHIB	Rigid Hull Inflatable Boat	RIB-4	5.0	100%	340.0	100%	0%	0%	340.0	0.0	0.0	0.34	9.1	0.1	1.4	0.2	115.6	3107.6	20.4	489.6	51.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
14	Land Demolition Training																																		
15	Insertion/Extraction	0																																	
16	NSW Training	35		RHIB	Rigid Hull Inflatable Boat	RIB-4	6.0	100%	210.0	100%	0%	0%	210.0	0.0	0.0	0.34	9.1	0.1	1.4	0.2	71.4	1919.4	12.6	302.4	31.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
		70		SDB	Seal Delivery Vehicle		6.0	100%	420.0	100%	0%	0%	420.0	0.0	0.0																				
17	HARMEX	0																																	
18	ISR	0																																	
19	UAV	0																																	
	Total	901														Total Emissions tons					1.44	3.31	0.13	0.61	0.08	8.67	6.48	0.86	2.28	0.48	172.20	110.91	15.80	29.76	6.18
																Total Emissions within US Territory					10.11	9.80	1.00	2.89	0.56										

Table C-4. Aircraft Air Emissions—No Action Alternative

Scenario No.	Type Training	A/C Sorties No.	Nomenclature	Ave. A/C Time on Range (hrs) Hours	Total Time on Range (hrs) Hours	% Below 3,000 ft %	Time Below 3,000 ft Hours	Percentage 0-3 nm from shore (Percent)	Percentage 3-12 nm from Shore (Percent)	Percentage >12 nm from Shore (Percent)	Total Time 0-3 nm from shore (Hours)	Total Time 3-12 nm from shore (Hours)	Total Time >12 nm from shore (Hours)	Scenario No.	Aircraft Type	Engines Engine Model	No.	Fuel Flow lbs/hr	Emission Indices, lbs/1,000 lbs fuel CO	NOx	HC	SOx	PM10	Emissions Factors (lb/hr) CO	NOx	HC	SOx	PM10	Emissions 0-3 nm Offshore (lbs) CO	NOx	HC	SOx	PM	Emissions 3-12 nm Offshore—US Territory (lbs) CO	NOx	HC	SOx	PM	Emissions >12 nm Offshore—Outside US Territory CO	NOx	HC	SOx	PM
Training Operations																																											
1	Air Combat Maneuvers	4	FA-18E/F	1.5	6.0			100%							FA-18E/F	F414-GE-400 (assume approach)	2	4049	0.89	11.58	0.12	0.40	6.31	7.21	93.77	0.97	3.24	51.10															
		2021	EA-6B	1.5	3031.5			100%							EA-6B	J52-P-408A (assume approach)	2	4227	5.19	6.77	0.84	0.40	10.48	43.88	57.23	7.10	3.38	88.60															
		18	F-16	1.5	27.0			100%							F-16	F110-GE-400 (assume approach)	1	3859	1.35	8.44	0.76	0.40	5.98	5.21	32.57	2.93	1.54	23.08															
2	A-A MISSILEX		EA16G	2.0						100%					EA16G	J52-P-408A (assume approach)	2	4227	5.19	6.77	0.84	0.40	10.48	43.88	57.23	7.10	3.38	88.60															
3	S-A GUNEX	18	Learjet	3.0	54.0	50%	27.0	1%	2%	97%	0.27	0.54	26.19		Learjet	TFE 731-2-2B	2	531.76	22.38	5.90	4.28	0.54	4.20	23.80	6.27	4.55	0.57	4.47	6.43	1.69	1.23	0.16	1.21	12.85	3.39	2.46	0.31	2.41	623.36	164.34	119.21	15.04	116.99
4	S-A MISSILEX		P-3	3.0		67%		1%	2%	97%					P-3	T56-A-14 (assume ASUW)	4	1200	1.82	8.43	0.41	0.40	3.97	8.74	40.46	1.97	1.92	19.06															
			Learjet	3.0		67%		1%	2%	97%					Learjet	TFE 731-2-2B	2	531.76	22.38	5.90	4.28	0.54	4.20	23.80	6.27	4.55	0.57	4.47															
			C-130	3.0		67%		1%	2%	97%					C-130	T56-A-425 (assume approach)	4	850	4.03	6.71	0.97	0.40	3.97	13.70	22.81	3.30	1.36	13.50															
5	S-S GUNEX																																										
6	A-S BOMBEX	24	P-3	1.0	24.0	90%	21.6	1%	2%	97%	0.22	0.43	20.95		P-3	T56-A-14 (assume ASUW)	4	1200	1.82	8.43	0.41	0.40	3.97	8.74	40.46	1.97	1.92	19.06	1.89	8.74	0.43	0.41	4.12	3.77	17.48	0.85	0.83	8.23	183.04	847.80	41.23	40.23	399.26
7	SINKEX	2	E-2	16.0	32.0	10%	3.2			100%			3.20		E-2	T56-A-425 (assume 30% SHP)	2	1100	2.16	8.06	0.49	0.40	3.97	4.75	17.73	1.08	0.88	8.73											15.21	56.74	3.45	2.82	27.95
		8	FA-18E/F	16.0	128.0	10%	12.8			100%			12.80		FA-18E/F	F414-GE-400 (assume approach)	2	4049	0.89	11.58	0.12	0.40	6.31	7.21	93.77	0.97	3.24	51.10											92.25	1200.32	12.44	41.46	654.06
		1	P-3	16.0	16.0	10%	1.6			100%			1.60		P-3	T56-A-14 (assume ASUW)	4	1200	1.82	8.43	0.41	0.40	3.97	8.74	40.46	1.97	1.92	19.06											13.98	64.74	3.15	3.07	30.49
		2	SH-60B	16.0	32.0	10%	3.2			100%			3.20		SH-60B	T700-GE-401C	2	600	6.25	6.40	0.55	0.40	4.20	7.50	7.68	0.66	0.48	5.04											24.00	24.58	2.11	1.54	16.13
8	MPA ASW TRACKEX	200	P-3	6.0	1200.0	75%	900.0	5%	10%	85%	45.00	90.00	765.00		P-3	T56-A-14 (assume ASUW)	4	1200	1.82	8.43	0.41	0.40	3.97	8.74	40.46	1.97	1.92	19.06	393.12	1820.88	88.56	86.40	857.52	786.24	3641.76	177.12	172.80	1715.04	6683.04	30954.96	1505.52	1468.80	14577.84
9	EER/IEER ASW	10	P-3	6.0	60.0	50%	30.0	17%	17%	66%	5.10	5.10	19.80		P-3	T56-A-14 (assume ASUW)	4	1200	1.82	8.43	0.41	0.40	3.97	8.74	40.46	1.97	1.92	19.06	44.55	206.37	10.04	9.79	97.19	44.55	206.37	10.04	9.79	97.19	172.97	801.19	38.97	38.02	377.31
10	Surface Ship ASW TRACKEX																																										
11	Submarine ASW TORPEX																																										
12	Electronic Combat Exercise	13	P-3	1.5	19.5				3%	97%					P-3	T56-A-14 (assume ASUW)	4	1200	1.82	8.43	0.41	0.40	3.97	8.74	40.46	1.97	1.92	19.06															
		182	EP-3	1.5	273.0				3%	97%					EP-3	T56-A-14 (assume ASUW)	4	1200	1.82	8.43	0.41	0.40	3.97	8.74	40.46	1.97	1.92	19.06															
		2135	EA-6B	1.5	3202.5				3%	97%					EA-6B	J52-P-408A (assume approach)	2	4227	5.19	6.77	0.84	0.40	10.48	43.88	57.23	7.10	3.38	88.60															
13	Mine Countermeasures	10	SH-60B	2.0	20.0	100%	20.0	100%			20.00				SH-60B	T700-GE-401C	2	600	6.25	6.40	0.55	0.40	4.20	7.50	7.68	0.66	0.48	5.04	150.00	153.60	13.20	9.60	100.80										
14	Land Demolition Training																																										
15	Insertion/Extraction	24	C-130	1.0	24.0			100%							C-130	T56-A-425 (assume approach)	4	850	4.03	6.71	0.97	0.40	3.97	13.70	22.81	3.30	1.36	13.50															
		84	SH-60B	2.0	168.0	100%	168.0	100%			168.00				SH-60B	T700-GE-401C	2	600	6.25	6.40	0.55	0.40	4.20	7.50	7.68	0.66	0.48	5.04	1260.00	1290.24	110.88	80.64	846.72										
16	NSW Training																																										
17	HARMEX	2724	EA-6B	1.5	4086.0				3%	97%					EA-6B	J52-P-408A (assume approach)	2	4227	5.19	6.77	0.84	0.40	10.48	43.88	57.23	7.10	3.38	88.60															
18	ISR	94	P-3	6.0	564.0	40%	225.6			100%			225.60		P-3	T56-A-14 (assume ASUW)	4	1200	1.82	8.43	0.41	0.40	3.97	8.74	40.46	1.97	1.92	19.06											1970.84	9128.68	443.98	433.15	4299.03
																		hp	lbs/hp-hr																								
19	UAV	12	Scan Eagle	6.0	72.0	100%	72.0	100%			72.00				Scan Eagle	2.5 hp engine	1	2.5	6.68E-03	3.10E-02	2.51E-03	2.05E-03	2.20E-03	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.00	0.00	0.00										
	Totals	7586																						**Total Emissions tons**					**0.93**	**1.74**	**0.11**	**0.09**	**0.95**	**0.42**	**1.93**	**0.10**	**0.09**	**0.91**	**4.89**	**21.62**	**1.09**	**1.02**	**10.25**
																								Total Emissions within US Territory					**1.35**	**3.68**	**0.21**	**0.19**	**1.87**										

Table C-5. Aircraft Air Emissions—Alternative 1

Scenario	Type Training	A/C Sorties	Nomenclature	Ave. A/C Time on Range (hrs)	Total Time on Range (hrs)	% Below 3,000 ft	Time Below 3,000 ft	Percentage 0-3 nm from shore	Percentage 3-12 nm from Shore	Percentage >12 nm from Shore	Total Time 0-3 nm from shore	Total Time 3-12 nm from shore	Total Time >12 nm from shore	Scenario	Aircraft	Engines		Fuel Flow	Emission Indices, lbs/1,000 lbs fuel					Emissions Factors (lb/hr)					Emissions: Emissions 0-3 nm Offshore (lbs)					Emissions 3-12 nm Offshore—US Territory (lbs)					Emissions >12 nm Offshore—Outside US Territory				
		No.		Hours	Hours	%	Hours	Percent			Hours			No.	Type	Engine Model	No.	lbs/hr	CO	NOx	HC	SOx	PM10	CO	NOx	HC	SOx	PM10	CO	NOx	HC	SOx	PM	CO	NOx	HC	SOx	PM	CO	NOx	HC	SOx	PM
Training Operations																																											
1	Air Combat Maneuvers	6	FA-18E/F	1.5	9.0			100%							FA-18E/F	F414-GE-400 (assume approach)	2	4049	0.89	11.58	0.12	0.40	6.31	7.21	93.77	0.97	3.24	51.10															
		2987	EA-6B	1.5	4480.5			100%							EA-6B	J52-P-408A (assume approach)	2	4227	5.19	6.77	0.84	0.40	10.48	43.88	57.23	7.10	3.38	88.60															
		27	F-16	1.5	40.5			100%							F-16	F110-GE-400 (assume approach)	1	3859	1.35	8.44	0.76	0.40	5.98	5.21	32.57	2.93	1.54	23.08															
2	A-A MISSILEX	48	EA16G	2.0	96.0					100%					EA16G	J52-P-408A (assume approach)	2	4227	5.19	6.77	0.84	0.40	10.48	43.88	57.23	7.10	3.38	88.60															
3	S-A GUNEX	20	Learjet	3.0	60.0	50%	30.0	1%	2%	97%	0.30	0.60	29.10		Learjet	TFE 731-2-2B	2	531.76	22.38	5.90	4.28	0.54	4.20	23.80	6.27	4.55	0.57	4.47	7.14	1.88	1.37	0.17	1.34	14.28	3.76	2.73	0.34	2.68	692.63	182.60	132.46	16.71	129.98
4	S-A MISSILEX		P-3	3.0		67%		1%	2%	97%					P-3	T56-A-14 (assume ASUW)	4	1200	1.82	8.43	0.41	0.40	3.97	8.74	40.46	1.97	1.92	19.06															
			Learjet	3.0		67%		1%	2%	97%					Learjet	TFE 731-2-2B	2	531.76	22.38	5.90	4.28	0.54	4.20	23.80	6.27	4.55	0.57	4.47															
			C-130	3.0		67%		1%	2%	97%					C-130	T56-A-425 (assume approach)	4	850	4.03	6.71	0.97	0.40	3.97	13.70	22.81	3.30	1.36	13.50															
5	S-S GUNEX																																										
6	A-S BOMBEX	30	P-3	1.0	30.0	90%	27.0	1%	2%	97%	0.27	0.54	26.19		P-3	T56-A-14 (assume ASUW)	4	1200	1.82	8.43	0.41	0.40	3.97	8.74	40.46	1.97	1.92	19.06	2.36	10.93	0.53	0.52	5.15	4.72	21.85	1.06	1.04	10.29	228.80	1059.75	51.54	50.28	499.08
7	SINKEX	4	E-2	16.0	64.0	10%	6.4			100%			6.40		E-2	T56-A-425 (assume 30% SHP)	2	1100	2.16	8.06	0.49	0.40	3.97	4.75	17.73	1.08	0.88	8.73											30.41	113.48	6.90	5.63	55.90
		16	FA-18E/F	16.0	256.0	10%	25.6			100%			25.60		FA-18E/F	F414-GE-400 (assume approach)	2	4049	0.89	11.58	0.12	0.40	6.31	7.21	93.77	0.97	3.24	51.10											184.50	2400.64	24.88	82.92	1308.12
		2	P-3	16.0	32.0	10%	3.2			100%			3.20		P-3	T56-A-14 (assume ASUW)	4	1200	1.82	8.43	0.41	0.40	3.97	8.74	40.46	1.97	1.92	19.06											27.96	129.48	6.30	6.14	60.98
		4	SH-60B	16.0	64.0	10%	6.4			100%			6.40		SH-60B	T700-GE-401C	2	600	6.25	6.40	0.55	0.40	4.20	7.50	7.68	0.66	0.48	5.04											48.00	49.15	4.22	3.07	32.26
8	MPA ASW TRACKEX	205	P-3	6.0	1230.0	75%	922.5	5%	10%	85%	46.13	92.25	784.13		P-3	T56-A-14 (assume ASUW)	4	1200	1.82	8.43	0.41	0.40	3.97	8.74	40.46	1.97	1.92	19.06	402.95	1866.40	90.77	88.56	878.96	805.90	3732.80	181.55	177.12	1757.92	6850.12	31728.83	1543.16	1505.52	14942.29
9	EER/IEER ASW	11	P-3	6.0	66.0	50%	33.0	17%	17%	66%	5.61	5.61	21.78		P-3	T56-A-14 (assume ASUW)	4	1200	1.82	8.43	0.41	0.40	3.97	8.74	40.46	1.97	1.92	19.06	49.01	227.00	11.04	10.77	106.90	49.01	227.00	11.04	10.77	106.90	190.27	881.31	42.86	41.82	415.04
10	Surface Ship ASW TRACKEX																																										
11	Submarine ASW TORPEX																																										
12	Electronic Combat Exercise	14	P-3	1.5	21.0				3%	97%					P-3	T56-A-14 (assume ASUW)	4	1200	1.82	8.43	0.41	0.40	3.97	8.74	40.46	1.97	1.92	19.06															
		195	EP-3	1.5	292.5				3%	97%					EP-3	T56-A-14 (assume ASUW)	4	1200	1.82	8.43	0.41	0.40	3.97	8.74	40.46	1.97	1.92	19.06															
		2291	EA-6B	1.5	3436.5				3%	97%					EA-6B	J52-P-408A (assume approach)	2	4227	5.19	6.77	0.84	0.40	10.48	43.88	57.23	7.10	3.38	88.60															
13	Mine Countermeasures	12	SH-60B	2.0	24.0	100%	24.0	100%			24.00				SH-60B	T700-GE-401C	2	600	6.25	6.40	0.55	0.40	4.20	7.50	7.68	0.66	0.48	5.04	180.00	184.32	15.84	11.52	120.96										
14	Land Demolition Training																																										
15	Insertion/Extraction	27	C-130	1.0	27.0			100%							C-130	T56-A-425 (assume approach)	4	850	4.03	6.71	0.97	0.40	3.97	13.70	22.81	3.30	1.36	13.50															
		93	SH-60B	2.0	186.0	100%	186.0	100%			186.00				SH-60B	T700-GE-401C	2	600	6.25	6.40	0.55	0.40	4.20	7.50	7.68	0.66	0.48	5.04	1395.00	1428.48	122.76	89.28	937.44										
16	NSW Training																																										
17	HARMEX	3000	EA-6B	1.5	4500.0				3%	97%					EA-6B	J52-P-408A (assume approach)	2	4227	5.19	6.77	0.84	0.40	10.48	43.88	57.23	7.10	3.38	88.60															
18	ISR	100	P-3	6.0	600.0	40%	240.0			100%			240.00		P-3	T56-A-14 (assume ASUW)	4	1200	1.82	8.43	0.41	0.40	3.97	8.74	40.46	1.97	1.92	19.06											2096.64	9711.36	472.32	460.80	4573.44
																		hp																									
19	UAV	12	Scan Eagle	6.0	72.0	10%	7.2	100%			7.20				Scan Eagle	2.5 hp engine	1	2.5	6.68E-03	3.10E-02	2.51E-03	2.05E-03	2.20E-03	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00										
		100	Global Hawk	6.0	600.0	10%	60.0	100%			60.00				Global Hawk	2.5 hp engine	1	2.5	6.68E-03	3.10E-02	2.51E-03	2.05E-03	2.20E-03	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00										
	Totals	9204																						**Total Emissions tons**					**1.02**	**1.86**	**0.12**	**0.10**	**1.03**	**0.44**	**1.99**	**0.10**	**0.09**	**0.94**	**5.17**	**23.13**	**1.14**	**1.09**	**11.01**

Table C-6. Aircraft Air Emissions—Alternative 2

Scenario	Type Training	A/C Sorties (No.)	Nomenclature	Ave. A/C Time on Range (hrs) (Hours)	Total Time on Range (hrs) (Hours)	% Below 3,000 ft (%)	Time Below 3,000 ft (Hours)	Percentage 0-3 nm from shore (Percent)	Percentage 3-12 nm from Shore (Percent)	Percentage >12 nm from Shore (Percent)	Total Time 0-3 nm from shore (Hours)	Total Time 3-12 nm from shore (Hours)	Total Time >12 nm from shore (Hours)	Aircraft Type	Engines Engine Model	No.	Fuel Flow lbs/hr	Emission Indices, lbs/1,000 lbs fuel CO	NOx	HC	SOx	PM10	Emissions Factors (lb/hr) CO	NOx	HC	SOx	PM10	Emissions 0-3 nm Offshore (lbs) CO	NOx	HC	SOx	PM	Emissions 3-12 nm Offshore—US Territory (lbs) CO	NOx	HC	SOx	PM	Emissions >12 nm Offshore—Outside US Territory CO	NOx	HC	SOx	PM
Training Operations																																										
1	Air Combat Maneuvers	6	FA-18E/F	1.5	9.0			100%						FA-18E/F	F414-GE-400 (assume approach)	2	4049	0.89	11.58	0.12	0.40	6.31	7.21	93.77	0.97	3.24	51.10															
		2987	EA-6B	1.5	4480.5			100%						EA-6B	J52-P-408A (assume approach)	2	4227	5.19	6.77	0.84	0.40	10.48	43.88	57.23	7.10	3.38	88.60															
		27	F-16	1.5	40.5			100%						F-16	F110-GE-400 (assume approach)	1	3859	1.35	8.44	0.76	0.40	5.98	5.21	32.57	2.93	1.54	23.08															
2	A-A MISSILEX	96	EA16G	2.0	192.0					100%				EA16G	J52-P-408A (assume approach)	2	4227	5.19	6.77	0.84	0.40	10.48	43.88	57.23	7.10	3.38	88.60															
3	S-A GUNEX	40	Learjet	3.0	120.0	50%	60.0	1%	2%	97%	0.60	1.20	58.20	Learjet	TFE 731-2-2B	2	531.76	22.38	5.90	4.28	0.54	4.20	23.80	6.27	4.55	0.57	4.47	14.28	3.76	2.73	0.34	2.68	28.56	7.53	5.46	0.69	5.36	1385.25	365.19	264.92	33.42	259.97
4	S-A MISSILEX	4	P-3	3.0	12.0	67%	8.0	1%	2%	97%	0.08	0.16	7.76	P-3	T56-A-14 (assume ASUW)	4	1200	1.82	8.43	0.41	0.40	3.97	8.74	40.46	1.97	1.92	19.06	0.70	3.24	0.16	0.15	1.53	1.40	6.48	0.32	0.31	3.05	67.83	314.16	15.28	14.91	147.95
		4	Learjet	3.0	12.0	67%	8.0	1%	2%	97%	0.08	0.16	7.76	Learjet	TFE 731-2-2B	2	531.76	22.38	5.90	4.28	0.54	4.20	23.80	6.27	4.55	0.57	4.47	1.91	0.50	0.36	0.05	0.36	3.81	1.00	0.73	0.09	0.72	184.79	48.72	35.34	4.46	34.68
			C-130	3.0		67%		1%	2%	97%				C-130	T56-A-425 (assume approach)	4	850	4.03	6.71	0.97	0.40	3.97	13.70	22.81	3.30	1.36	13.50															
5	S-S GUNEX																																									
6	A-S BOMBEX	30	P-3	1.0	30.0	90%	27.0	1%	2%	97%	0.27	0.54	26.19	P-3	T56-A-14 (assume ASUW)	4	1200	1.82	8.43	0.41	0.40	3.97	8.74	40.46	1.97	1.92	19.06	2.36	10.93	0.53	0.52	5.15	4.72	21.85	1.06	1.04	10.29	228.80	1059.75	51.54	50.28	499.08
7	SINKEX	4	E-2	16.0	64.0	10%	6.4			100%			6.40	E-2	T56-A-425 (assume 30% SHP)	2	1100	2.16	8.06	0.49	0.40	3.97	4.75	17.73	1.08	0.88	8.73											30.41	113.48	6.90	5.63	55.90
		16	FA-18E/F	16.0	256.0	10%	25.6			100%			25.60	FA-18E/F	F414-GE-400 (assume approach)	2	4049	0.89	11.58	0.12	0.40	6.31	7.21	93.77	0.97	3.24	51.10											184.50	2400.64	24.88	82.92	1308.12
		2	P-3	16.0	32.0	10%	3.2			100%			3.20	P-3	T56-A-14 (assume ASUW)	4	1200	1.82	8.43	0.41	0.40	3.97	8.74	40.46	1.97	1.92	19.06											27.96	129.48	6.30	6.14	60.98
		4	SH-60B	16.0	64.0	10%	6.4			100%			6.40	SH-60B	T700-GE-401C	2	600	6.25	6.40	0.55	0.40	4.20	7.50	7.68	0.66	0.48	5.04											48.00	49.15	4.22	3.07	32.26
8	MPA ASW TRACKEX	210	P-3	6.0	1260.0	75%	945.0	5%	10%	85%	47.25	94.50	803.25	P-3	T56-A-14 (assume ASUW)	4	1200	1.82	8.43	0.41	0.40	3.97	8.74	40.46	1.97	1.92	19.06	412.78	1911.92	92.99	90.72	900.40	825.55	3823.85	185.98	181.44	1800.79	7017.19	32502.71	1580.80	1542.24	15306.73
9	EER/IEER ASW	12	P-3	6.0	72.0	50%	36.0	17%	17%	66%	6.12	6.12	23.76	P-3	T56-A-14 (assume ASUW)	4	1200	1.82	8.43	0.41	0.40	3.97	8.74	40.46	1.97	1.92	19.06	53.46	247.64	12.04	11.75	116.62	53.46	247.64	12.04	11.75	116.62	207.57	961.42	46.76	45.62	452.77
10	Surface Ship ASW TRACKEX																																									
11	Submarine ASW TORPEX																																									
12	Electronic Combat Exercise	28	P-3	1.5	42.0				3%	97%				P-3	T56-A-14 (assume ASUW)	4	1200	1.82	8.43	0.41	0.40	3.97	8.74	40.46	1.97	1.92	19.06															
		391	EP-3	1.5	586.5				3%	97%				EP-3	T56-A-14 (assume ASUW)	4	1200	1.82	8.43	0.41	0.40	3.97	8.74	40.46	1.97	1.92	19.06															
		4582	EA-6B	1.5	6873.0				3%	97%				EA-6B	J52-P-408A (assume approach)	2	4227	5.19	6.77	0.84	0.40	10.48	43.88	57.23	7.10	3.38	88.60															
13	Mine Countermeasures	12	SH-60B	2.0	24.0	100%	24.0	100%			24.00			SH-60B	T700-GE-401C	2	600	6.25	6.40	0.55	0.40	4.20	7.50	7.68	0.66	0.48	5.04	180.00	184.32	15.84	11.52	120.96										
14	Land Demolition Training																																									
15	Insertion/Extraction	27	C-130	1.0	27.0			100%						C-130	T56-A-425 (assume approach)	4	850	4.03	6.71	0.97	0.40	3.97	13.70	22.81	3.30	1.36	13.50															
		93	SH-60B	2.0	186.0	100%	186.0	100%			186.00			SH-60B	T700-GE-401C	2	600	6.25	6.40	0.55	0.40	4.20	7.50	7.68	0.66	0.48	5.04	1395.00	1428.48	122.76	89.28	937.44										
16	NSW Training																																									
17	HARMEX	3000	EA-6B	1.5	4500.0				3%	97%				EA-6B	J52-P-408A (assume approach)	2	4227	5.19	6.77	0.84	0.40	10.48	43.88	57.23	7.10	3.38	88.60															
18	ISR	100	P-3	6.0	600.0	40%	240.0			100%			240.00	P-3	T56-A-14 (assume ASUW)	4	1200	1.82	8.43	0.41	0.40	3.97	8.74	40.46	1.97	1.92	19.06											2096.64	9711.36	472.32	460.80	4573.44
																	hp																									
19	UAV	12	Scan Eagle	6.0	72.0	10%	7.2	100%			7.20			Scan Eagle	2.5 hp engine	1	2.5	6.68E-03	3.10E-02	2.51E-03	2.05E-03	2.20E-03	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00										
		100	Global Hawk	6.0	600.0	10%	60.0	100%			60.00			Global Hawk	2.5 hp engine	1	2.5	6.68E-03	3.10E-02	2.51E-03	2.05E-03	2.20E-03	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00										
	Totals	11787																					**Total Emissions tons**					**1.03**	**1.90**	**0.12**	**0.10**	**1.04**	**0.46**	**2.05**	**0.10**	**0.10**	**0.97**	**5.74**	**23.83**	**1.25**	**1.12**	**11.37**
																							Total Emissions within US Territory					**1.49**	**3.95**	**0.23**	**0.20**	**2.01**										

Table C-7. Ordnance Expenditures—Baseline

		NOTE: Units of Measure (UOM) for ordnance rounds are 1 each (ea.) and for Demolitions and Other Ordnance are in pounds Net Explosive Weight (NEW).				Emission Factor (lb per lb or lb per item)							Emissions, tons/year						
Ordnance Group	AQ Data	Ordnance Type	Quantity Fired	NEW ea.	UOM/ Cum NEW	CO2	CO	Nox	PM10	PM2.5	SO2	Lead	CO2	CO	Nox	PM10	PM2.5	SO2	Lead
BOMB		CBU MK20 ROCKEYE		99	ea.														
	No Data	GBU32I JDAM		385	ea.														
	No Data	LGTR		0	ea.														
		MK76		Neg.	ea.														
	No Data	BDU 48		Neg.	ea.														
		MK82 HE	12	192	ea.		0.3184						0	0.3667968	0	0	0	0	0
	No Data	GBU12 500 lb		192	ea.														
	NA	MK82 INERT	88	0	ea.														
	No Data	BDU 45		0	ea.														
		MK83 HE	4	445	ea.		0.1482						0	0.131898	0	0	0	0	0
	No Data	GBU 16		445	ea.														
	NA	MK83 INERT		0	ea.														
		Total:	**104**																
OTHER ORD	**No AQ data**	**Type**	**No.**	**NEW**															
	CNAP & SPAWAR	EER/IEER AN/SQQ-110	124	4.2	520.8	1.2	0.0044	0.011				0.00004	0.31248	0.0011458	0.0028644	0	0	0	0.000010416
	No Data	BLASTING CAP MK11	2,890	Neg.	0														
	No Data	FIRING DEVICE	97	Neg.	0														
		Fuse	17,340																
	No Data	Igniters	510	Neg.	0														
		GRENADE SIMULATOR		0.0813	0.0	6.30E-01	0.021	6.30E-03	2.10E-02	1.50E-02	1.20E-04	1.40E-04	0	0	0	0	0	0	0
		Grenades	170	0.0813	13.8	6.30E-01	0.021	6.30E-03	2.10E-02	1.50E-02	1.20E-04	1.40E-04	0.0043536	0.0001451	4.35362E-05	0.0001451	0.000104	8.2926E-07	9.6747E-07
	No Data	M1A2 BANGALORE TORP		10.00	0								0	0	0	0	0	0	0
		M7 BANDOLEER MK57 (Claymore mine)		8.16	0		0.15108						0	0	0	0	0	0	0
	AP-42	M112 DEMO CHARGE	1,060	1.20	1272	7.90E-01	2.60E-02	7.90E-03	2.60E-02	1.90E-02		1.70E-04	0.50244	0.016536	0.0050244	0.016536	0.012084	0	0.00010812
	No Data	M700 BLASTING FUSE		0.001	0														
	No Data	MK20 Cable Cutter		0.0028	0.0														
	No Data	MK22 Projectile Unit		Neg.	Neg.														
	No Data	MK36 M0 DEMO CHARGE		4.10	0								0	0	0	0	0	0	0
	No Data	MK75 CHARGE		50.00	0								0	0	0	0	0	0	0
	No Data	MK84 [86] EOD Shaped Charge	4	0.08	0.32								0	0	0	0	0	0	0
	No Data	MK120 NONELEC DET (ft)		0.00001	0.0000														
	No Data	MK123 NONELEC DET (ft)		0.00001	0.0000														
	No Data	MK138 DEMO CHG ASSEMBLY		20.00	0	6.30E-01	0.021	6.30E-03	2.10E-02	1.50E-02	1.20E-04	1.40E-04	0	0	0	0	0	0	0
	No Data	MK140 FLEXIBLE CHARGE		0.04	0														
		MK174	901																
	No Data	PBXN-109 TEST Det Cord		0.0060	0														
	No Data	SIGNAL MK 18(G950) SMOKE		0.23	0														
	No Data	C4 0.5 LB	3	0.50	1.5	6.30E-01	0.021	6.30E-03	2.10E-02	1.50E-02	1.20E-04	1.40E-04	4.73E-04	1.575E-05	0.000004725	1.575E-05	1.13E-05	0.00000009	0.000000105
	No Data	C4 2.5 LB	51	2.50	127.5	6.30E-01	0.021	6.30E-03	2.10E-02	1.50E-02	1.20E-04	1.40E-04	4.02E-02	0.0013388	0.000401625	0.0013388	0.000956	0.00000765	0.000008925
	No Data	C4 5 LB	511	5.00	2555	6.30E-01	0.021	6.30E-03	2.10E-02	1.50E-02	1.20E-04	1.40E-04	0.804825	0.0268275	0.00804825	0.0268275	0.019163	0.0001533	0.00017885
	No Data	C4 20 LB	65	20.00	1300	6.30E-01	0.021	6.30E-03	2.10E-02	1.50E-02	1.20E-04	1.40E-04	0.4095	0.01365	0.004095	0.01365	0.00975	0.000078	0.000091
	No Data	C4 300 LB		1.00	0	6.30E-01	0.021	6.30E-03	2.10E-02	1.50E-02	1.20E-04	1.40E-04	0	0	0	0	0	0	0
	No Data	C4 500 LB		1.00	0	6.30E-01	0.021	6.30E-03	2.10E-02	1.50E-02	1.20E-04	1.40E-04	0	0	0	0	0	0	0
	No Data	TNT Blocks 0.5 lbd		1.00	0		0.398							0					
	No Data	DEMO SHEET	1,105	6.00	6630														
	No Data	DETONATING CORD	34,000	0.006	204														
	No Data	DEMO CHARGE		5.00	0														
	AP-42	SIMULATED ARTILLERY		0.1375	0	6.30E-01	0.021	6.30E-03	2.10E-02	1.50E-02	1.20E-04	1.40E-04	0	0	0	0	0	0	0
		Totals	**-58,831**		**12,625**														
GUNFIRE (Large)	AP-42	155MM HE			ea.	6.51	2.35E+01	1.43E+00	0.496	0.2418		2.26E-03	0	0	0	0	0	0	0
	AP-42	155MM ILL			ea.	1.8	2.62E-02	9.40E-02	3	3		5.80E-05	0	0	0	0	0	0	0
5"/54		5"/54 BLP	1,216		ea.	1.60E-02	2.00E-02		1.20E-03	9.30E-04		6.00E-06	0.009728	0.01216	0	0.0007296	0.000565	0	0.000003648
		5"/54 HCVT+32 (EOD)			ea.	1.60E-02	2.00E-02		1.20E-03	9.30E-04		6.00E-06	0	0	0	0	0	0	0
		5"/54 HECVT			ea.	1.60E-02	2.00E-02		1.20E-03	9.30E-04		6.00E-06	0	0	0	0	0	0	0
		5"/54 HEPD			ea.	1.60E-02	2.00E-02		1.20E-03	9.30E-04		6.00E-06	0	0	0	0	0	0	0
		5"/54 HEVT			ea.	1.60E-02	2.00E-02		1.20E-03	9.30E-04		6.00E-06	0	0	0	0	0	0	0
		5"/54 ILL			ea.	1.50E-02	1.40E-02	3.60E-04	9.20E-04	7.60E-04		1.30E-06	0	0	0	0	0	0	0
		5"54/54 VTNF			ea.	1.60E-02	2.00E-02		1.20E-03	9.30E-04		6.00E-06	0	0	0	0	0	0	0
5"/62		5"/62	500		ea.	1.60E-02	2.00E-02		1.20E-03	9.30E-04		6.00E-06	0.004	0.005	0	0.0003	0.000233	0	0.0000015
		5"/62 HE-MFF			ea.	1.60E-02	2.00E-02		1.20E-03	9.30E-04		6.00E-06	0	0	0	0	0	0	0
		5"/62 HECVT			ea.	1.60E-02	2.00E-02		1.20E-03	9.30E-04		6.00E-06	0	0	0	0	0	0	0
		5"/62 HEET			ea.	1.60E-02	2.00E-02		1.20E-03	9.30E-04		6.00E-06	0	0	0	0	0	0	0
		5"/62 KEET			ea.	1.60E-02	2.00E-02		1.20E-03	9.30E-04		6.00E-06	0	0	0	0	0	0	0
60mm	AP-42	60MM	630		ea.	2.90E-01	3.00E-02	4.20E-03	3.20E-02	1.70E-02		2.30E-04	0.09135	0.00945	0.001323	0.01008	0.005355	0	0.00007245
		60MM WP			ea.	2.90E-01	3.00E-02	4.20E-03	3.20E-02	1.70E-02		2.30E-04	0	0	0	0	0	0	0
76mm		76MM BLP	560		ea.	1.44E-02	1.80E-02		1.08E-03	8.37E-04		5.40E-06	0.004032	0.00504	0	0.0003024	0.000234	0	0.000001512
	AP-42	81MM HE			ea.	1.60E-02	2.00E-02		1.20E-03	9.30E-04		6.00E-06	0	0	0	0	0	0	0
	AP-42	81MM ILL			ea.	1.50E-02	1.40E-02	3.60E-04	9.20E-04	7.60E-04		1.30E-06	0	0	0	0	0	0	0
CAS	No data	GAU-17 30mm			ea.														
		Total:	**2,906**																
GUNFIRE (small)	AMW 114,1125	20MM	7,200		ea.	2.60E-04	3.50E-04	3.60E-05	2.60E-05	2.30E-05		6.70E-04	0.000936	0.00126	0.0001296	0.0000936	8.28E-05	0	0.002412
		25MM	15,750		ea.	2.60E-04	3.50E-04	3.60E-05	2.60E-05	2.30E-05		6.70E-04	0.0020475	0.0027563	0.0002835	0.0002048	0.000181	0	0.00527625
	No Data	30MM EFV Main Gun			ea.														
	AP-42	40MM			ea.	2.60E-04	3.50E-04	3.60E-05	2.60E-05	2.30E-05		6.70E-04	0	0	0	0	0	0	0
	AP-42	40MM HE			ea.	6.60E-02	7.00E-03	1.60E-03	1.30E-02	6.60E-03		7.30E-05	0	0	0	0	0	0	0
	No Data	40MM ILL			ea.	2.60E-04	3.50E-04	3.60E-05	2.60E-05	2.30E-05		6.70E-04	0	0	0	0	0	0	0
	AP-42	40MM PRACTICE			ea.	2.60E-04	3.50E-04	3.60E-05	2.60E-05	2.30E-05		6.70E-04	0	0	0	0	0	0	0
	AP-42	.45 CAL			ea.	2.20E-04	2.60E-04	8.10E-06	3.70E-05	3.10E-05		1.20E-05	0	0	0	0	0	0	0
	AP-42	5.56			ea.	8.70E-04	1.60E-03	8.50E-05	3.90E-05	2.80E-05		5.10E-06	0	0	0	0	0	0	0
	AP-42	5.56 BLANK			ea.	2.30E-04	2.80E-04	2.00E-05	6.90E-06	2.00E-06		9.70E-07	0	0	0	0	0	0	0
	AP-42	.50CAL	58,500		ea.	5.10E-03	1.10E-02	1.20E-03	3.10E-04	1.90E-04		1.30E-05	0.149175	0.32175	0.0351	0.0090675	0.005558	0	0.00038025
		.50CAL			ea.	5.10E-03	1.10E-02	1.20E-03	3.10E-04	1.90E-04		1.30E-05	0	0	0	0	0	0	0
	AP-42	.50CAL BLANK			ea.	2.10E-03	1.80E-03	2.80E-05	9.80E-05	8.80E-05		1.20E-05	0	0	0	0	0	0	0
	AP-42	7.62	1,224		ea.	1.20E-03	2.30E-03	9.70E-05	5.10E-05	3.80E-05		4.90E-06	0.0007344	0.0014076	0.000059364	3.121E-05	2.33E-05	0	2.9988E-06
		7.62			ea.	1.20E-03	2.30E-03	9.70E-05	5.10E-05	3.80E-05		4.90E-06	0	0	0	0	0	0	0
	AP-42	9MM			ea.	2.00E-04	3.10E-04	1.50E-05	2.40E-05	2.00E-05		6.80E-06	0	0	0	0	0	0	0
	No Data	.300 WIN MAG			ea.	2.00E-04	3.10E-04	1.50E-05	2.40E-05	2.00E-05		6.80E-06	0	0	0	0	0	0	0
	No Data	.223 Rifle Rounds			ea.	6.80E-05	7.20E-05	3.10E-06	2.60E-06	1.90E-06		1.80E-06	0	0	0	0	0	0	0
	No Data	.22 Magnum			ea.	7.50E-05	8.00E-05	5.00E-06	3.40E-06	2.60E-06		1.90E-06	0	0	0	0	0	0	0
	AP-42	.22 Long Rifle			ea.	6.80E-05	7.20E-05	3.10E-06	2.60E-06	1.90E-06		1.80E-06	0	0	0	0	0	0	0
		12 Guage Shotgun			ea.	5.10E-03	1.10E-02	1.20E-03	3.10E-04	1.90E-04		1.30E-05	0	0	0	0	0	0	0
		Total:	**82,674**																
MINE SHAPE	AP-42	M18A1			ea.	1.6	2.00E-02	1.80E-02	4.90E-02	2.60E-02		5.70E-05	0	0	0	0	0	0	0
		MK76			ea.														
		MK62			ea.	No emissions													
		Total:	**0**																
MISSILE		AGM-114B	1		ea.														
		AGM-65 Maverick	3		ea.														
		AGM-84 Harpoon	3		ea.														
		AIM-120			ea.														
		AIM-7			ea.														
		AIM-9			ea.														
		BGM-71E TOW-A			ea.														
		HARM	2		ea.														
AW 25		NSM			ea.														
		JSOW			ea.														
		Japanese Missile Tests			ea.														
		Tactical Tomahawk			ea.														
		SLAM	1		ea.														
		SM2 or equivalent	1		ea.														
		Total:	**11**																
ROCKET		2.75" RKT			ea.	4.50E-01	5.60E-02	7.10E-03	6.10E-02	3.80E-02		1.20E-03	0	0	0	0	0	0	0
		2.75" RKT HE			ea.	4.50E-01	5.60E-02	7.10E-03	6.10E-02	3.80E-02		1.20E-03	0	0	0	0	0	0	0
		2.75" RKT I			ea.	4.50E-01	5.60E-02	7.10E-03	6.10E-02	3.80E-02		1.20E-03	0	0	0	0	0	0	0
		Total:	**0**																
FLARES		**FLARES****			**ea.**														
SMOKE		MK58 Marine Location Marker	8		ea.	1	1.30E-02	1.20E-02	3.20E-02	1.70E-02	6.10E-05	3.80E-05	0.004	0.000052	0.000048	0.000128	0.000068	0.000000244	0.000000152
		SMOKE GRENADE	739		ea.	1	1.30E-02	1.20E-02	3.20E-02	1.70E-02	6.10E-05	3.80E-05	0.3695	0.0048035	0.004434	0.011824	0.006282	2.25395E-05	0.000014041
		Total:	**747**																
TORPEDO	NA	MK46			ea.														
	NA	MK48-ADCAP	1		ea.														
		Total:	**1**																
		GRAND TOTAL ROUNDS	**27,612**																
		GRAND TOTAL POUNDS NEW			**12,625**														
											NWTRC		2.7097365	0.922033	0.0618594	0.0912742	0.060649	0.000262653	0.008563185

Table C-8. Ordnance Expenditures—Alternative 1

NOTE: Units of Measure (UOM) for ordnance rounds are 1 each (ea.) and for Demolitions and Other Ordnance are in pounds Net Explosive Weight (NEW).						Emission Factor (lb per lb or lb per item)							Emissions, tons/year						
Ordnance Group	**AQ Data**	**Ordnance Type**	**Quantity Fired**	**NEW ea.**	**UOM/ Cum NEW**	**CO2**	**CO**	**Nox**	**PM10**	**PM2.5**	**SO2**	**Lead**	**CO2**	**CO**	**Nox**	**PM10**	**PM2.5**	**SO2**	**Lead**
BOMB		CBU MK20 ROCKEYE		99	ea.														
	No Data	GBU32I JDAM		385	ea.														
	No Data	LGTR		0	ea.														
		MK76		Neg.	ea.														
	No Data	BDU 48		Neg.	ea.														
		MK82 HE	18	192	ea.		0.3184						0	0.550195	0	0	0	0	0
	No Data	GBU12 500 lb		192	ea.														
	NA	MK82 INERT	110	0	ea.														
	No Data	BDU 45		0	ea.														
		MK83 HE	8	445	ea.		0.1482						0	0.263796	0	0	0	0	0
	No Data	GBU 16		445	ea.														
	NA	MK83 INERT		0	ea.														
		Total:	**136**																
OTHER ORD	**No AQ data**	**Type**	**No.**	**NEW**															
	CNAP & SPAWAR	EER/IEER AN/SQQ-110	136	4.2	571.2	1.2	0.0044	0.011				0.00004	0.34272	0.001257	0.0031416	0	0	0	1.14E-05
	No Data	BLASTING CAP MK11	3,117	Neg.	0														
	No Data	FIRING DEVICE	105	Neg.	0														
		Fuse	18,700																
	No Data	Igniters	550	Neg.	0														
		GRENADE SIMULATOR		0.0813	0.0	6.30E-01	0.021	6.30E-03	2.10E-02	1.50E-02	1.20E-04	1.40E-04	0	0	0	0	0	0	0
		Grenades	183	0.0813	14.9	6.30E-01	0.021	6.30E-03	2.10E-02	1.50E-02	1.20E-04	1.40E-04	0.004687	0.000156	4.68654E-05	0.000156	0.000112	8.92674E-07	1.04E-06
	No Data	M1A2 BANGALORE TORP		10.00	0								0	0	0	0	0	0	0
		M7 BANDOLEER MK57 (Claymore mine)		8.16	0		0.15108						0	0	0	0	0	0	0
	AP-42	M112 DEMO CHARGE	1,143	1.20	1371.6	7.90E-01	2.60E-02	7.90E-03	2.60E-02	1.90E-02		1.70E-04	0.541782	0.017831	0.00541782	0.017831	0.01303	0	0.000117
	No Data	M700 BLASTING FUSE		0.001	0														
	No Data	MK20 Cable Cutter		0.0028	0.0														
	No Data	MK22 Projectile Unit		Neg.	Neg.														
	No Data	MK36 M0 DEMO CHARGE		4.10	0								0	0	0	0	0	0	0
	No Data	MK75 CHARGE		50.00	0								0	0	0	0	0	0	0
	No Data	MK84 [86] EOD Shaped Charge	8	0.08	0.64								0	0	0	0	0	0	0
	No Data	MK120 NONELEC DET (ft)		0.00001	0.0000														
	No Data	MK123 NONELEC DET (ft)		0.00001	0.0000														
	No Data	MK138 DEMO CHG ASSEMBLY		20.00	0	6.30E-01	0.021	6.30E-03	2.10E-02	1.50E-02	1.20E-04	1.40E-04	0	0	0	0	0	0	0
	No Data	MK140 FLEXIBLE CHARGE		0.04	0														
		MK174	972																
	No Data	PBXN-109 TEST Det Cord		0.0060	0														
	No Data	SIGNAL MK 18(G950) SMOKE		0.23	0														
	No Data	C4 0.5 LB	4	0.50	2	6.30E-01	0.021	6.30E-03	2.10E-02	1.50E-02	1.20E-04	1.40E-04	6.30E-04	0.000021	0.0000063	0.000021	0.000015	0.00000012	1.4E-07
	No Data	C4 2.5 LB	60	2.50	150	6.30E-01	0.021	6.30E-03	2.10E-02	1.50E-02	1.20E-04	1.40E-04	4.73E-02	0.001575	0.0004725	0.001575	0.001125	0.000009	1.05E-05
	No Data	C4 5 LB	551	5.00	2755	6.30E-01	0.021	6.30E-03	2.10E-02	1.50E-02	1.20E-04	1.40E-04	0.867825	0.028928	0.00867825	0.028928	0.020663	0.0001653	0.000193
	No Data	C4 20 LB	76	20.00	1520	6.30E-01	0.021	6.30E-03	2.10E-02	1.50E-02	1.20E-04	1.40E-04	0.4788	0.01596	0.004788	0.01596	0.0114	0.0000912	0.000106
	No Data	C4 300 LB		1.00	0	6.30E-01	0.021	6.30E-03	2.10E-02	1.50E-02	1.20E-04	1.40E-04	0	0	0	0	0	0	0
	No Data	C4 500 LB		1.00	0	6.30E-01	0.021	6.30E-03	2.10E-02	1.50E-02	1.20E-04	1.40E-04	0	0	0	0	0	0	0
	No Data	TNT Blocks 0.5 lbd		1.00	0		0.398							0					
	No Data	DEMO SHEET	1,192	6.00	7152														
	No Data	DETONATING CORD	36,667	0.006	220.002														
	No Data	DEMO CHARGE		5.00	0														
	AP-42	SIMULATED ARTILLERY		0.1375	0	6.30E-01	0.021	6.30E-03	2.10E-02	1.50E-02	1.20E-04	1.40E-04	0	0	0	0	0	0	0
		Totals	**63,464**		**13,757**														
GUNFIRE (Large)	AP-42	155MM HE			ea.	6.51	2.35E+01	1.43E+00	0.496	0.2418		2.26E-03	0	0	0	0	0	0	0
	AP-42	155MM ILL			ea.	1.8	2.62E-02	9.40E-02	3	3		5.80E-05	0	0	0	0	0	0	0
5"/54		5"/54 BLP	1,351		ea.	1.60E-02	2.00E-02		1.20E-03	9.30E-04		6.00E-06	0.010808	0.01351	0	0.000811	0.000628	0	4.05E-06
		5"/54 HCVT+32 (EOD)			ea.	1.60E-02	2.00E-02		1.20E-03	9.30E-04		6.00E-06	0	0	0	0	0	0	0
		5"/54 HECVT			ea.	1.60E-02	2.00E-02		1.20E-03	9.30E-04		6.00E-06	0	0	0	0	0	0	0
		5"/54 HEPD			ea.	1.60E-02	2.00E-02		1.20E-03	9.30E-04		6.00E-06	0	0	0	0	0	0	0
		5"/54 HEVT			ea.	1.60E-02	2.00E-02		1.20E-03	9.30E-04		6.00E-06	0	0	0	0	0	0	0
		5"/54 ILL			ea.	1.50E-02	1.40E-02	3.60E-04	9.20E-04	7.60E-04		1.30E-06	0	0	0	0	0	0	0
		5"54/54 VTNF			ea.	1.60E-02	2.00E-02		1.20E-03	9.30E-04		6.00E-06	0	0	0	0	0	0	0
5"/62		5"/62	1,000		ea.	1.60E-02	2.00E-02		1.20E-03	9.30E-04		6.00E-06	0.008	0.01	0	0.0006	0.000465	0	0.000003
		5"/62 HE-MFF			ea.	1.60E-02	2.00E-02		1.20E-03	9.30E-04		6.00E-06	0	0	0	0	0	0	0
		5"/62 HECVT			ea.	1.60E-02	2.00E-02		1.20E-03	9.30E-04		6.00E-06	0	0	0	0	0	0	0
		5"/62 HEET			ea.	1.60E-02	2.00E-02		1.20E-03	9.30E-04		6.00E-06	0	0	0	0	0	0	0
		5"/62 KEET			ea.	1.60E-02	2.00E-02		1.20E-03	9.30E-04		6.00E-06	0	0	0	0	0	0	0
60mm	AP-42	60MM	700		ea.	2.90E-01	3.00E-02	4.20E-03	3.20E-02	1.70E-02		2.30E-04	0.1015	0.0105	0.00147	0.0112	0.00595	0	8.05E-05
		60MM WP			ea.	2.90E-01	3.00E-02	4.20E-03	3.20E-02	1.70E-02		2.30E-04	0	0	0	0	0	0	0
76mm		76MM BLP	800		ea.	1.44E-02	1.80E-02		1.08E-03	8.37E-04		5.40E-06	0.00576	0.0072	0	0.000432	0.000335	0	2.16E-06
	AP-42	81MM HE			ea.	1.60E-02	2.00E-02		1.20E-03	9.30E-04		6.00E-06	0	0	0	0	0	0	0
	AP-42	81MM ILL			ea.	1.50E-02	1.40E-02	3.60E-04	9.20E-04	7.60E-04		1.30E-06	0	0	0	0	0	0	0
CAS	No data	GAU-17 30mm			ea.														
		Total:	**3,851**																
GUNFIRE (small)	AMW 114,1125	20MM	11,600		ea.	2.60E-04	3.50E-04	3.60E-05	2.60E-05	2.30E-05		6.70E-04	0.001508	0.00203	0.0002088	0.000151	0.000133	0	0.003886
		25MM	17,500		ea.	2.60E-04	3.50E-04	3.60E-05	2.60E-05	2.30E-05		6.70E-04	0.002275	0.003063	0.000315	0.000228	0.000201	0	0.005863
	No Data	30MM EFV Main Gun			ea.														
	AP-42	40MM			ea.	2.60E-04	3.50E-04	3.60E-05	2.60E-05	2.30E-05		6.70E-04	0	0	0	0	0	0	0
	AP-42	40MM HE			ea.	6.60E-02	7.00E-03	1.60E-03	1.30E-02	6.60E-03		7.30E-05	0	0	0	0	0	0	0
	No Data	40MM ILL			ea.	2.60E-04	3.50E-04	3.60E-05	2.60E-05	2.30E-05		6.70E-04	0	0	0	0	0	0	0
	AP-42	40MM PRACTICE			ea.	2.60E-04	3.50E-04	3.60E-05	2.60E-05	2.30E-05		6.70E-04	0	0	0	0	0	0	0
	AP-42	.45 CAL			ea.	2.20E-04	2.60E-04	8.10E-06	3.70E-05	3.10E-05		1.20E-05	0	0	0	0	0	0	0
	AP-42	5.56			ea.	8.70E-04	1.60E-03	8.50E-05	3.90E-05	2.80E-05		5.10E-06	0	0	0	0	0	0	0
	AP-42	5.56 BLANK			ea.	2.30E-04	2.80E-04	2.00E-05	6.90E-06	2.00E-06		9.70E-07	0	0	0	0	0	0	0
	AP-42	.50CAL	65,000		ea.	5.10E-03	1.10E-02	1.20E-03	3.10E-04	1.90E-04		1.30E-05	0.16575	0.3575	0.039	0.010075	0.006175	0	0.000423
		.50CAL			ea.	5.10E-03	1.10E-02	1.20E-03	3.10E-04	1.90E-04		1.30E-05	0	0	0	0	0	0	0
	AP-42	.50CAL BLANK			ea.	2.10E-03	1.80E-03	2.80E-05	9.80E-05	8.80E-05		1.20E-05	0	0	0	0	0	0	0
	AP-42	7.62	1,360		ea.	1.20E-03	2.30E-03	9.70E-05	5.10E-05	3.80E-05		4.90E-06	0.000816	0.001564	0.00006596	3.47E-05	2.58E-05	0	3.33E-06
		7.62			ea.	1.20E-03	2.30E-03	9.70E-05	5.10E-05	3.80E-05		4.90E-06	0	0	0	0	0	0	0
	AP-42	9MM			ea.	2.00E-04	3.10E-04	1.50E-05	2.40E-05	2.00E-05		6.80E-06	0	0	0	0	0	0	0
	No Data	.300 WIN MAG			ea.	2.00E-04	3.10E-04	1.50E-05	2.40E-05	2.00E-05		6.80E-06	0	0	0	0	0	0	0
	No Data	.223 Rifle Rounds			ea.	6.80E-05	7.20E-05	3.10E-06	2.60E-06	1.90E-06		1.80E-06	0	0	0	0	0	0	0
	No Data	.22 Magnum			ea.	7.50E-05	8.00E-05	5.00E-06	3.40E-06	2.60E-06		1.90E-06	0	0	0	0	0	0	0
	AP-42	.22 Long Rifle			ea.	6.80E-05	7.20E-05	3.10E-06	2.60E-06	1.90E-06		1.80E-06	0	0	0	0	0	0	0
		12 Guage Shotgun			ea.	5.10E-03	1.10E-02	1.20E-03	3.10E-04	1.90E-04		1.30E-05	0	0	0	0	0	0	0
		Total:	**95,460**																
MINE SHAPE	AP-42	M18A1			ea.	1.6	2.00E-02	1.80E-02	4.90E-02	2.60E-02		5.70E-05	0	0	0	0	0	0	0
		MK76			ea.														
		MK62			ea.	No emissions													
		Total:	**0**																
MISSILE		AGM-114B	2		ea.														
		AGM-65 Maverick	6		ea.														
		AGM-84 Harpoon	6		ea.														
		AIM-120	4		ea.														
		AIM-7	6		ea.														
		AIM-9	5		ea.														
		BQM74E	4		ea.														
		HARM	4		ea.														
		NSM			ea.														
AW 25		JSOW			ea.														
		Japanese Missile Tests			ea.														
		Seasparrow	2		ea.														
		SLAM	2		ea.														
		SM2 or equivalent	2		ea.														
		Total:	**43**																
ROCKET		2.75" RKT			ea.	4.50E-01	5.60E-02	7.10E-03	6.10E-02	3.80E-02		1.20E-03	0	0	0	0	0	0	0
		2.75" RKT HE			ea.	4.50E-01	5.60E-02	7.10E-03	6.10E-02	3.80E-02		1.20E-03	0	0	0	0	0	0	0
		2.75" RKT I			ea.	4.50E-01	5.60E-02	7.10E-03	6.10E-02	3.80E-02		1.20E-03	0	0	0	0	0	0	0
		Total:	**0**																
FLARES		**FLARES****			**ea.**														
SMOKE		MK58 Marine Location Marker	8		ea.	1	1.30E-02	1.20E-02	3.20E-02	1.70E-02	6.10E-05	3.80E-05	0.004	0.000052	0.000048	0.000128	0.000068	0.000000244	1.52E-07
		SMOKE GRENADE	787		ea.	1	1.30E-02	1.20E-02	3.20E-02	1.70E-02	6.10E-05	3.80E-05	0.3935	0.005116	0.004722	0.012592	0.00669	2.40035E-05	1.5E-05
		Total:	**795**																
TORPEDO	NA	MK46			ea.														
	NA	MK48-ADCAP	2		ea.														
		Total:	**2**																
		GRAND TOTAL ROUNDS	**163,751**																
		GRAND TOTAL POUNDS NEW			**13,757**														
											NWTRC		2.977611	1.290252	0.068381095	0.100721	0.067015	0.00029076	0.010718

Table C-9. Ordnance Expenditures—Alternative 2

	NOTE: Units of Measure (UOM) for ordnance rounds are 1 each (ea.) and for Demolitions and Other Ordnance are in pounds Net Explosive Weight (NEW).					Emission Factor (lb per lb or lb per item)							Emissions, tons/year						
Ordnance Group	**AQ Data**	**Ordnance Type**	**Quantity Fired**	**NEW ea.**	**UOM/ Cum NEW**	**CO2**	**CO**	**Nox**	**PM10**	**PM2.5**	**SO2**	**Lead**	**CO2**	**CO**	**Nox**	**PM10**	**PM2.5**	**SO2**	**Lead**
BOMB		CBU MK20 ROCKEYE		99	ea.														
	No Data	GBU32I JDAM		385	ea.														
	No Data	LGTR		0	ea.														
		MK76		Neg.	ea.														
	No Data	BDU 48		Neg.	ea.														
		MK82 HE	18	192	ea.		0.3184						0	0.550195	0	0	0	0	0
	No Data	GBU12 500 lb		192	ea.														
	NA	MK82 INERT	110	0	ea.														
	No Data	BDU 45		0	ea.														
		MK83 HE	8	445	ea.		0.1482						0	0.263796	0	0	0	0	0
	No Data	GBU 16		445	ea.														
	NA	MK83 INERT		0	ea.														
		Total:	**136**																
OTHER ORD	**No AQ data**	**Type**	**No.**	**NEW**															
	CNAP & SPAWAR	EER/IEER AN/SQQ-110	149	4.2	625.8	1.2	0.0044	0.011				0.00004	0.37548	0.001377	0.0034419	0	0	0	1.25E-05
	No Data	BLASTING CAP MK11	3,117	Neg.	0														
	No Data	FIRING DEVICE	105	Neg.	0														
		Fuse	18,700																
	No Data	Igniters	550	Neg.	0														
		GRENADE SIMULATOR		0.0813	0.0	6.30E-01	0.021	6.30E-03	2.10E-02	1.50E-02	1.20E-04	1.40E-04	0	0	0	0	0	0	0
		Grenades	183	0.0813	14.9	6.30E-01	0.021	6.30E-03	2.10E-02	1.50E-02	1.20E-04	1.40E-04	0.004687	0.000156	4.68654E-05	0.000156	0.000112	8.92674E-07	1.04E-06
	No Data	M1A2 BANGALORE TORP		10.00	0								0	0	0	0	0	0	0
		M7 BANDOLEER MK57 (Claymore mine)		8.16	0		0.15108						0	0	0	0	0	0	0
	AP-42	M112 DEMO CHARGE	1,143	1.20	1371.6	7.90E-01	2.60E-02	7.90E-03	2.60E-02	1.90E-02		1.70E-04	0.541782	0.017831	0.00541782	0.017831	0.01303	0	0.000117
	No Data	M700 BLASTING FUSE		0.001	0														
	No Data	MK20 Cable Cutter		0.0028	0.0														
	No Data	MK22 Projectile Unit		Neg.	Neg.														
	No Data	MK36 M0 DEMO CHARGE		4.10	0								0	0	0	0	0	0	0
	No Data	MK75 CHARGE		50.00	0								0	0	0	0	0	0	0
	No Data	MK84 [86] EOD Shaped Charge	8	0.08	0.64								0	0	0	0	0	0	0
	No Data	MK120 NONELEC DET (ft)		0.00001	0.0000														
	No Data	MK123 NONELEC DET (ft)		0.00001	0.0000														
	No Data	MK138 DEMO CHG ASSEMBLY		20.00	0	6.30E-01	0.021	6.30E-03	2.10E-02	1.50E-02	1.20E-04	1.40E-04	0	0	0	0	0	0	0
	No Data	MK140 FLEXIBLE CHARGE		0.04	0														
		MK174	972																
	No Data	PBXN-109 TEST Det Cord		0.0060	0														
	No Data	SIGNAL MK 18(G950) SMOKE		0.23	0														
	No Data	C4 0.5 LB	4	0.50	2	6.30E-01	0.021	6.30E-03	2.10E-02	1.50E-02	1.20E-04	1.40E-04	6.30E-04	0.000021	0.0000063	0.000021	0.000015	0.00000012	1.4E-07
	No Data	C4 2.5 LB	60	2.50	150	6.30E-01	0.021	6.30E-03	2.10E-02	1.50E-02	1.20E-04	1.40E-04	4.73E-02	0.001575	0.0004725	0.001575	0.001125	0.000009	1.05E-05
	No Data	C4 5 LB	551	5.00	2755	6.30E-01	0.021	6.30E-03	2.10E-02	1.50E-02	1.20E-04	1.40E-04	0.867825	0.028928	0.00867825	0.028928	0.020663	0.0001653	0.000193
	No Data	C4 20 LB	76	20.00	1520	6.30E-01	0.021	6.30E-03	2.10E-02	1.50E-02	1.20E-04	1.40E-04	0.4788	0.01596	0.004788	0.01596	0.0114	0.0000912	0.000106
	No Data	C4 300 LB		1.00	0	6.30E-01	0.021	6.30E-03	2.10E-02	1.50E-02	1.20E-04	1.40E-04	0	0	0	0	0	0	0
	No Data	C4 500 LB		1.00	0	6.30E-01	0.021	6.30E-03	2.10E-02	1.50E-02	1.20E-04	1.40E-04	0	0	0	0	0	0	0
	No Data	TNT Blocks 0.5 lbd		1.00	0		0.398							0					
	No Data	DEMO SHEET	1,192	6.00	7152														
	No Data	DETONATING CORD	36,667	0.006	220.002														
	No Data	DEMO CHARGE		5.00	0														
	AP-42	SIMULATED ARTILLERY		0.1375	0	6.30E-01	0.021	6.30E-03	2.10E-02	1.50E-02	1.20E-04	1.40E-04	0	0	0	0	0	0	0
		Totals	**63,477**		**13,812**														
GUNFIRE (Large)	AP-42	155MM HE			ea.	6.51	2.35E+01	1.43E+00	0.496	0.2418		2.26E-03	0	0	0	0	0	0	0
	AP-42	155MM ILL			ea.	1.8	2.62E-02	9.40E-02	3	3		5.80E-05	0	0	0	0	0	0	0
5"/54		5"/54 BLP	2,463		ea.	1.60E-02	2.00E-02		1.20E-03	9.30E-04		6.00E-06	0.019704	0.02463	0	0.001478	0.001145	0	7.39E-06
		5"/54 HCVT+32 (EOD)			ea.	1.60E-02	2.00E-02		1.20E-03	9.30E-04		6.00E-06	0	0	0	0	0	0	0
		5"/54 HECVT			ea.	1.60E-02	2.00E-02		1.20E-03	9.30E-04		6.00E-06	0	0	0	0	0	0	0
		5"/54 HEPD			ea.	1.60E-02	2.00E-02		1.20E-03	9.30E-04		6.00E-06	0	0	0	0	0	0	0
		5"/54 HEVT			ea.	1.60E-02	2.00E-02		1.20E-03	9.30E-04		6.00E-06	0	0	0	0	0	0	0
		5"/54 ILL			ea.	1.50E-02	1.40E-02	3.60E-04	9.20E-04	7.60E-04		1.30E-06	0	0	0	0	0	0	0
		5"54/54 VTNF			ea.	1.60E-02	2.00E-02		1.20E-03	9.30E-04		6.00E-06	0	0	0	0	0	0	0
5"/62		5"/62	1,000		ea.	1.60E-02	2.00E-02		1.20E-03	9.30E-04		6.00E-06	0.008	0.01	0	0.0006	0.000465	0	0.000003
		5"/62 HE-MFF			ea.	1.60E-02	2.00E-02		1.20E-03	9.30E-04		6.00E-06	0	0	0	0	0	0	0
		5"/62 HECVT			ea.	1.60E-02	2.00E-02		1.20E-03	9.30E-04		6.00E-06	0	0	0	0	0	0	0
		5"/62 HEET			ea.	1.60E-02	2.00E-02		1.20E-03	9.30E-04		6.00E-06	0	0	0	0	0	0	0
		5"/62 KEET			ea.	1.60E-02	2.00E-02		1.20E-03	9.30E-04		6.00E-06	0	0	0	0	0	0	0
60mm	AP-42	60MM	1,260		ea.	2.90E-01	3.00E-02	4.20E-03	3.20E-02	1.70E-02		2.30E-04	0.1827	0.0189	0.002646	0.02016	0.01071	0	0.000145
		60MM WP			ea.	2.90E-01	3.00E-02	4.20E-03	3.20E-02	1.70E-02		2.30E-04	0	0	0	0	0	0	0
76mm		76MM BLP	1,120		ea.	1.44E-02	1.80E-02		1.08E-03	8.37E-04		5.40E-06	0.008064	0.01008	0	0.000605	0.000469	0	3.02E-06
	AP-42	81MM HE			ea.	1.60E-02	2.00E-02		1.20E-03	9.30E-04		6.00E-06	0	0	0	0	0	0	0
	AP-42	81MM ILL			ea.	1.50E-02	1.40E-02	3.60E-04	9.20E-04	7.60E-04		1.30E-06	0	0	0	0	0	0	0
CAS	No data	GAU-17 30mm			ea.														
		Total:	**5,843**																
GUNFIRE (small)	AMW 114,1125	20MM	23,200		ea.	2.60E-04	3.50E-04	3.60E-05	2.60E-05	2.30E-05		6.70E-04	0.003016	0.00406	0.0004176	0.000302	0.000267	0	0.007772
		25MM	31,500		ea.	2.60E-04	3.50E-04	3.60E-05	2.60E-05	2.30E-05		6.70E-04	0.004095	0.005513	0.000567	0.00041	0.000362	0	0.010553
	No Data	30MM EFV Main Gun			ea.														
	AP-42	40MM			ea.	2.60E-04	3.50E-04	3.60E-05	2.60E-05	2.30E-05		6.70E-04	0	0	0	0	0	0	0
	AP-42	40MM HE			ea.	6.60E-02	7.00E-03	1.60E-03	1.30E-02	6.60E-03		7.30E-05	0	0	0	0	0	0	0
	No Data	40MM ILL			ea.	2.60E-04	3.50E-04	3.60E-05	2.60E-05	2.30E-05		6.70E-04	0	0	0	0	0	0	0
	AP-42	40MM PRACTICE			ea.	2.60E-04	3.50E-04	3.60E-05	2.60E-05	2.30E-05		6.70E-04	0	0	0	0	0	0	0
	AP-42	.45 CAL			ea.	2.20E-04	2.60E-04	8.10E-06	3.70E-05	3.10E-05		1.20E-05	0	0	0	0	0	0	0
	AP-42	5.56			ea.	8.70E-04	1.60E-03	8.50E-05	3.90E-05	2.80E-05		5.10E-06	0	0	0	0	0	0	0
	AP-42	5.56 BLANK			ea.	2.30E-04	2.80E-04	2.00E-05	6.90E-06	2.00E-06		9.70E-07	0	0	0	0	0	0	0
	AP-42	.50CAL	117,000		ea.	5.10E-03	1.10E-02	1.20E-03	3.10E-04	1.90E-04		1.30E-05	0.29835	0.6435	0.0702	0.018135	0.011115	0	0.000761
		.50CAL			ea.	5.10E-03	1.10E-02	1.20E-03	3.10E-04	1.90E-04		1.30E-05	0	0	0	0	0	0	0
	AP-42	.50CAL BLANK			ea.	2.10E-03	1.80E-03	2.80E-05	9.80E-05	8.80E-05		1.20E-05	0	0	0	0	0	0	0
	AP-42	7.62	2,720		ea.	1.20E-03	2.30E-03	9.70E-05	5.10E-05	3.80E-05		4.90E-06	0.001632	0.003128	0.00013192	6.94E-05	5.17E-05	0	6.66E-06
		7.62			ea.	1.20E-03	2.30E-03	9.70E-05	5.10E-05	3.80E-05		4.90E-06	0	0	0	0	0	0	0
	AP-42	9MM			ea.	2.00E-04	3.10E-04	1.50E-05	2.40E-05	2.00E-05		6.80E-06	0	0	0	0	0	0	0
	No Data	.300 WIN MAG			ea.	2.00E-04	3.10E-04	1.50E-05	2.40E-05	2.00E-05		6.80E-06	0	0	0	0	0	0	0
	No Data	.223 Rifle Rounds			ea.	6.80E-05	7.20E-05	3.10E-06	2.60E-06	1.90E-06		1.80E-06	0	0	0	0	0	0	0
	No Data	.22 Magnum			ea.	7.50E-05	8.00E-05	5.00E-06	3.40E-06	2.60E-06		1.90E-06	0	0	0	0	0	0	0
	AP-42	.22 Long Rifle			ea.	6.80E-05	7.20E-05	3.10E-06	2.60E-06	1.90E-06		1.80E-06	0	0	0	0	0	0	0
		12 Guage Shotgun			ea.	5.10E-03	1.10E-02	1.20E-03	3.10E-04	1.90E-04		1.30E-05	0	0	0	0	0	0	0
		Total:	**174,420**																
MINE SHAPE	AP-42	M18A1			ea.	1.6	2.00E-02	1.80E-02	4.90E-02	2.60E-02		5.70E-05	0	0	0	0	0	0	0
		MK76			ea.														
		MK62			ea.	No emissions													
		Total:	**0**																
MISSILE		AGM-114B	2		ea.														
		AGM-65 Maverick	6		ea.														
		AGM-84 Harpoon	6		ea.														
		AIM-120	7		ea.														
		AIM-7	13		ea.														
		AIM-9	9		ea.														
		BQM74E	16		ea.														
		HARM	4		ea.														
AW 25		NSM			ea.														
		JSOW			ea.														
		Japanese Missile Tests			ea.														
		Seasparrow	8		ea.														
		SLAM	2		ea.														
		SM2 or equivalent	2		ea.														
		Total:	**75**																
ROCKET		2.75" RKT			ea.	4.50E-01	5.60E-02	7.10E-03	6.10E-02	3.80E-02		1.20E-03	0	0	0	0	0	0	0
		2.75" RKT HE			ea.	4.50E-01	5.60E-02	7.10E-03	6.10E-02	3.80E-02		1.20E-03	0	0	0	0	0	0	0
		2.75" RKT I			ea.	4.50E-01	5.60E-02	7.10E-03	6.10E-02	3.80E-02		1.20E-03	0	0	0	0	0	0	0
		Total:	**0**																
FLARES		**FLARES****			**ea.**														
SMOKE		MK58 Marine Location Marker	8		ea.	1	1.30E-02	1.20E-02	3.20E-02	1.70E-02	6.10E-05	3.80E-05	0.004	0.000052	0.000048	0.000128	0.000068	0.000000244	1.52E-07
		SMOKE GRENADE	792		ea.	1	1.30E-02	1.20E-02	3.20E-02	1.70E-02	6.10E-05	3.80E-05	0.396	0.005148	0.004752	0.012672	0.006732	0.000024156	1.5E-05
		Total:	**800**																
TORPEDO	NA	MK46			ea.														
	NA	MK48-ADCAP	2		ea.														
		Total:	**2**																
		GRAND TOTAL ROUNDS	**244,753**																
		GRAND TOTAL POUNDS NEW			**13,812**														
											NWTRC		3.242015	1.604849	0.101614155	0.119029	0.077729	0.000290913	0.019705

Table C-10. Ground Vehicle Emissions - No Action Alternative

Scenario	Type Training	Days	Ground Vehicles	Number	Engine Load	Hours per day	Emissions Factors (lb/hr)					Emissions (lbs)				
Training Exercises							**CO**	**NOx**	**HC**	**SOx**	**PM10**	**CO**	**Nox**	**HC**	**Sox**	**PM**
1	Air Combat Maneuvers		None													
2	A-A Missiles		None													
3	S-A Gunnery Exercise		None													
4	S-A Missiles		None													
5	S-S GUNEX		None													
6	A-S BOMBEX		None													
7	SINKEX		None													
8	ASW TRACKEX - MPA		None													
9	EER-IEER		None													
10	Surface Ship ASW TRACKEX		None													
11	Sub ASW TRACKEX		None													
12	Elec Combat		None													
13	Mine Countermeasures Training		None													
14	Land Demolition Training	102	Pickup Trucks	12	1.0	8	0.30	0.03	0.02	0.00	0.00	2980.86	249.60	156.04	2.74	8.92
15	Insertion/Extraction		None													
16	NSW Training		None													
17	HARMEX		None													
18	ISR		None													
19	UAV		None													
	Total						**Total Ground Vehicle Emissions, tons**					1.49043095	0.1247989	0.078018	0.001371	0.004458

Table C-11. Ground Vehicle Emissions - Alternative 1

Scenario	Type Training	Days	Ground Vehicles	Number	Engine Load	Hours per day	Emissions Factors (lb/hr)					Emissions (lbs)				
Training Exercises							**CO**	**NOx**	**HC**	**SOx**	**PM10**	**CO**	**Nox**	**HC**	**Sox**	**PM**
1	Air Combat Maneuvers		None													
2	A-A Missiles		None													
3	S-A Gunnery Exercise		None													
4	S-A Missiles		None													
5	S-S GUNEX		None													
6	A-S BOMBEX		None													
7	SINKEX		None													
8	ASW TRACKEX - MPA		None													
9	EER-IEER		None													
10	Surface Ship ASW TRACKEX		None													
11	Sub ASW TRACKEX		None													
12	Elec Combat		None													
13	Mine Countermeasures Training		None													
14	Land Demolition Training	110	Pickup Trucks	13	1.0	8	0.30	0.03	0.02	0.00	0.00	3482.54	291.61	182.30	3.20	10.42
15	Insertion/Extraction		None													
16	NSW Training		None													
17	HARMEX		None													
18	ISR		None													
19	UAV		None													
	Total						**Total Ground Vehicle Emissions, tons**					1.74127146	0.1458027	0.091149	0.001602	0.005208

Table C-12. Ground Vehicle Emissions - Alternative 2

Scenario	Type Training	Days	Ground Vehicles	Number	Engine Load	Hours per day	Emissions Factors (lb/hr)					Emissions (lbs)				
Training Exercises							**CO**	**NOx**	**HC**	**SOx**	**PM10**	**CO**	**Nox**	**HC**	**Sox**	**PM**
1	Air Combat Maneuvers		None													
2	A-A Missiles		None													
3	S-A Gunnery Exercise		None													
4	S-A Missiles		None													
5	S-S GUNEX		None													
6	A-S BOMBEX		None													
7	SINKEX		None													
8	ASW TRACKEX - MPA		None													
9	EER-IEER		None													
10	Surface Ship ASW TRACKEX		None													
11	Sub ASW TRACKEX		None													
12	Elec Combat		None													
13	Mine Countermeasures Training		None													
14	Land Demolition Training	110	Pickup Trucks	13	1.0	8	0.30	0.03	0.02	0.00	0.00	3482.54	291.61	182.30	3.20	10.42
15	Insertion/Extraction		None													
16	NSW Training		None													
17	HARMEX		None													
18	ISR		None													
19	UAV		None													
	Total						**Total Ground Vehicle Emissions, tons**					1.74127146	0.1458027	0.091149	0.001602	0.005208

Table C-13. Total Emissions within 3 nm of Shore

No Action Alternative	CO	NOx	HC	SOx	PM10	PM2.5
Aircraft–Operations	0.93	1.74	0.11	0.09	0.95	0.94
Surface Ships	1.32	3.02	0.12	0.56	0.08	0.08
Ordnance	0.92	0.06	0.00	0.00	0.09	0.09
Ground Vehicles	1.49	0.12	0.08	0.00	0.00	0.00
Total	**4.66**	**4.95**	**0.31**	**0.65**	**1.13**	**1.12**
Alternative 1						
Aircraft–Operations	1.02	1.86	0.12	0.10	1.03	1.02
Surface Ships	1.44	3.31	0.13	0.61	0.08	0.08
Ordnance	1.29	0.07	0.00	0.00	0.10	0.10
Ground Vehicles	1.74	0.15	0.09	0.00	0.01	0.01
Total	**5.49**	**5.39**	**0.35**	**0.71**	**1.22**	**1.20**
Alternative 2						
Aircraft–Operations	1.03	1.90	0.12	0.10	1.04	1.03
Surface Ships	1.44	3.31	0.13	0.61	0.08	0.08
Ordnance	1.60	0.10	0.00	0.00	0.12	0.12
Ground Vehicles	1.74	0.15	0.09	0.00	0.01	0.01
Total	**5.81**	**5.46**	**0.35**	**0.71**	**1.25**	**1.24**
Increases over Baseline						
Alternative 1	0.82	0.44	0.03	0.06	0.09	0.09
Alternative 2	1.15	0.51	0.04	0.06	0.12	0.12
Major Source Threshold	**100.00**	**100.00**	**10.00**	**100.00**	**100.00**	**100.00**
Alternative 1 Above?	NO	NO	NO	NO	NO	NO
Alternative 2 Above?	NO	NO	NO	NO	NO	NO

Table C-14. Total Emissions within U.S. Territory

No Action Alternative	CO	NOx	HC	SOx	PM10	PM2.5
Aircraft–Operations	0.00	0.00	0.00	0.00	0.00	0.00
Surface Ships	0.00	0.00	0.00	0.00	0.00	0.00
Ordnance	0.00	0.00	0.00	0.00	0.00	0.00
Ground Vehicles	0.00	0.00	0.00	0.00	0.00	0.00
Total	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**
Alternative 1						
Aircraft–Operations	0.00	0.00	0.00	0.00	0.00	0.00
Surface Ships	0.00	0.00	0.00	0.00	0.00	0.00
Ordnance	0.00	0.00	0.00	0.00	0.00	0.00
Ground Vehicles	0.00	0.00	0.00	0.00	0.00	0.00
Total	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**
Alternative 2						
Aircraft–Operations	0.00	0.00	0.00	0.00	0.00	0.00
Surface Ships	0.00	0.00	0.00	0.00	0.00	0.00
Ordnance	0.00	0.00	0.00	0.00	0.00	0.00
Ground Vehicles	0.00	0.00	0.00	0.00	0.00	0.00
Total	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**
Increases over Baseline						
Alternative 1	0.00	0.00	0.00	0.00	0.00	0.00
Alternative 2	0.00	0.00	0.00	0.00	0.00	0.00
Major Source Threshold	**100.00**	**100.00**	**10.00**	**100.00**	**100.00**	**100.00**
Alternative 1 Above?	NO	NO	NO	NO	NO	NO
Alternative 2 Above?	NO	NO	NO	NO	NO	NO

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Appendix D

Marine Mammal Modeling

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D MARINE MAMMAL MODELING

D.1 BACKGROUND AND OVERVIEW

All marine mammals are protected under the Marine Mammal Protection Act (MMPA). The MMPA prohibits, with certain exceptions, the take of marine mammals in U.S. waters and by U.S. citizens on the high seas, and the importation of marine mammals and marine mammal products into the United States.

The Endangered Species Act of 1973 (ESA) provides for the conservation of species that are endangered or threatened throughout all or a significant portion of their range, and the conservation of their ecosystems. A species is considered endangered if it is in danger of extinction throughout all or a significant portion of its range. A species is considered threatened if it is likely to become an endangered species within the foreseeable future. There are marine mammals, already protected under MMPA, listed as either endangered or threatened under ESA, and afforded special protections.

Actions involving sound in the water include the potential to harass marine animals in the surrounding waters. Demonstration of compliance with MMPA and the ESA, using best available science, has been assessed using criteria and thresholds accepted or negotiated, and described here.

Sections of the MMPA (16 United States Code [U.S.C.] 1361 et seq.) direct the Secretary of Commerce to allow, upon request, the incidental, but not intentional, taking of small numbers of marine mammals by U.S. citizens who engage in a specified activity, other than commercial fishing, within a specified geographical region. Through a specific process, if certain findings are made and regulations are issued or, if the taking is limited to harassment, notice of a proposed authorization is provided to the public for review.

Authorization for incidental takings may be granted if the National Marine Fisheries Service (NMFS) finds that the taking will have no more than a negligible impact on the species or stock(s), will not have an 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 noise. For explosions of ordnance planned for use in the Northwest Training Range Complex (NWTRC), in the absence of any mitigation or monitoring measures, there is a very small chance that a marine mammal could be injured or killed when exposed to the energy generated from an explosive force.

Analysis of noise impacts is based on criteria and thresholds initially presented in U.S. Navy Environmental Impact Statements for ship shock trials of the Seawolf submarine and the Winston Churchill (DDG 81), and subsequently adopted by NMFS.

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 decibels (dB) re 1 micro Pascal squared–second (µPa2-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 pounds per square inch-millisecond (psi-msec), found to cause slight and extensive injury in a dolphin calf, were used as thresholds in the analysis contained in this document.

D.1.1 Metrics for Physiological Effect Thresholds

Effect thresholds used for acoustic impact modeling in this document are expressed in terms of EFD / Sound Exposure Level (SEL), which is total energy received over time in an area, or in terms of Sound Pressure Level (SPL), which is the level (root mean square) without reference to any time component for the exposure at that level. Marine and terrestrial mammal data show that, for continuous-type sounds of interest, Temporary Threshold Shift (TTS) and PTS are more closely related to the energy in the sound exposure than to the exposure SPL.

The Energy Level (EL) for each individual ping is calculated from the following equation:

EL = SPL + 10log10(duration)

The EL includes both the ping SPL and duration. Longer-duration pings and/or higher-SPL pings will have a higher EL.

If an animal is exposed to multiple pings, the EFD in each individual ping is summed to calculate the total EL. Since mammalian Threshold Shift (TS) data show less effect from intermittent exposures compared to continuous exposures with the same energy (Ward, 1997), basing the effect thresholds on the total received EL is a conservative approach for treating multiple pings; in reality, some recovery will occur between pings and lessen the effect of a particular exposure. Therefore, estimates are conservative because recovery is not taken into account (given that generally applicable recovery times have not been experimentally established) and as a result, intermittent exposures from sonar are modeled as if they were continuous exposures.

The total EL depends on the SPL, duration, and number of pings received. The TTS and PTS thresholds do not imply any specific SPL, duration, or number of pings. The SPL and duration of each received ping are used to calculate the total EL and determine whether the received EL meets or exceeds the effect thresholds. For example, the TTS threshold would be reached through any of the following exposures:

- A single ping with SPL = 195 dB re 1 µPa and duration = 1 second.
- A single ping with SPL = 192 dB re 1 µPa and duration = 2 seconds.
- Two pings with SPL = 192 dB re 1 µPa and duration = 1 second.

Two pings with SPL = 189 dB re 1 µPa and duration = 2 seconds.

D.1.2 Derivation of an Effects Threshold Based on EFD

As described in detail in Section 3.9.2.1 of the NWTRC EIS, SEL (EFD level) exposure threshold established for onset-TTS is 195 dB re 1 μPa^2-s. This result is corroborated by the short-duration tone data of Finneran et al. (2000, 2003) and the long-duration sound data from Nachtigall et al. (2003a, b). Together, these data demonstrate that TTS in small odontocetes is correlated with the received EL and that onset-TTS exposures are fit well by an equal-energy line passing through 195 dB re 1 μPa^2-s. Absent any additional data for other species and being that it is likely that small odontocetes are more sensitive to the mid-frequency active/high-frequency active (MFA/HFA) frequency levels of concern, this threshold is used for analysis for all cetacea.

The PTS thresholds established for use in this analysis are based on a 20 dB increase in exposure EL over that required for onset-TTS. The 20 dB value is based on estimates from terrestrial mammal data of PTS occurring at 40 dB or more of TS, and on TS growth occurring at a rate of 1.6 dB/dB increase in exposure EL. This is conservative because: (1) 40 dB of TS is actually an upper limit for TTS used to approximate onset-PTS, and (2) the 1.6 dB/dB growth rate is the highest observed in the data from Ward et al. (1958, 1959). Using this estimation method (20 dB up from onset-TTS) for the NWTRC analysis, the PTS threshold for cetacea is 215 dB re 1µPa2-s.

The threshold levels for analyzing acoustic impacts to pinnipeds from MFA/HFA sonar are based on specific species data when available. For the Stellar sea lion and Northern fur seal, the California sea lion data was used. Morphologically, the Stellar sea lion, Northern fur seal, and California sea lion are related. They are "eared" seals (Family Otarridae w/external ear flaps), vice the true seals (Family Phocidae w/out external ear flaps) such as harbor seals. In addition, the habitats and natural history (foraging, breeding, etc) are similar between Stellar sea lion, Northern fur seal, and California sea lion. The threshold levels for pinnipeds are given below:

Level A Harassment (onset PTS)

- Stellar Sea Lion 226 dB re 1 µPa2 ·s
- Northern Fur Seal 226 dB re 1 µPa2 ·s
- California Sea Lion 226 dB re 1 µPa2 ·s
- Northern Elephant Seal 224 dB re 1 µPa2 ·s
- Harbor Seal 203 dB re 1 µPa2 ·s

Level B Harassment (onset TTS)

- Stellar Sea Lion 206 dB re 1 µPa2 ·s
- Northern Fur Seal 206 dB re 1 µPa2 ·s
- California Sea Lion 206 dB re 1 µPa2 ·s
- Northern Elephant Seal 204 dB re 1 µPa2 ·s
- Harbor Seal 183 dB re 1 µPa2 ·s

Level B (non-injurious) Harassment also includes a TTS threshold consisting of 182 dB re 1 µPa2-s maximum EFD level in any 1/3-octave band above 100 hertz (Hz) for toothed whales (e.g., dolphins). A second criterion, 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 of 1 µPa2-s is not (Table D-1). NMFS applies the more conservative of these two.

For Multiple Successive Explosions (MSEs), the acoustic criterion for sub-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 sub-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 1 µPa2-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 1 µPa^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 sub-TTS threshold is therefore derived by subtracting 5 dB from the 182 dB re 1 µPa^2-s in any 1/3 octave band threshold, resulting in a 177 dB re 1 µPa^2-s (EL) sub-TTS behavioral disturbance threshold for MSE. Table D-1 lists the harassment thresholds for explosives.

Table D-1. Harassment Thresholds–Explosives

Threshold Type (Explosives)	Threshold Level
Sub-TTS Threshold for Multiple Successive Explosions (peak one-third octave energy)	177 dB
Level B - Temporary Threshold Shift (TTS) (peak one-third octave energy)	182 dB
Level B - Temporary Threshold Shift (TTS) (peak pressure)	23 psi
Level A – Slight lung injury (positive impulse)	13 psi-ms
Level A – 50% Eardrum rupture	205 dB
Mortality – 1% Mortal lung injury (positive impulse)	31 psi-ms

D.1.3 Derivation of a Behavioral Effect Threshold Based on SPL

Over the past several years, the Navy and NMFS have worked on developing alternative criteria to replace and/or to supplement the acoustic thresholds used in the past to estimate the probability of marine mammals being behaviorally harassed by received levels of MFA and HFA sonar. The Navy continues working with the NMFS to refine a mathematically representative curve for assessment of behavioral effects modeling associated with the use of MFA/HFA sonar. As detailed in Section 4.1.2, the NMFS Office of Protected Resources made the decision to use a risk function and applicable input parameters to estimate the probability of behavioral responses that NMFS would classify as harassment for the purposes of the MMPA given exposure to specific received levels of MFA/HFA sonar. This decision was based on the recommendation of the two NMFS scientists, consideration of the independent reviews from six scientists, and NMFS MMPA regulations affecting the Navy's use of Surveillance Towed Array Sensor System Low-Frequency Active (SURTASS LFA) sonar (DoN, 2002; National Oceanic and Atmospheric Administration [NOAA], 2007).

The particular acoustic risk function developed by the Navy and NMFS is derived from a solution in Feller (1968) with input parameters modified by NMFS for MFA/HFA sonar for mysticetes, odontocetes, and pinnipeds. In order to represent a probability of risk in developing this function, the function would have a value near zero at very low exposures, and a value near one for very high exposures. One class of functions that satisfies this criterion is cumulative probability distributions, a type of cumulative distribution function. In selecting a particular functional expression for risk, several criteria were identified:

- The function must use parameters to focus discussion on areas of uncertainty;
- The function should contain a limited number of parameters;
- The function should be capable of accurately fitting experimental data; and
- The function should be reasonably convenient for algebraic manipulations.

As described in 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% risk

A = risk transition sharpness parameter (10)

It is important to note that the probabilities associated with acoustic modeling do not represent an individual's probability of responding; they identify the proportion of an exposed population (as represented by an evenly distributed density of marine mammals per unit area) that is likely to respond to an exposure. In addition, modeling does not take into account reductions from any of the Navy's standard protective mitigation measures which should significantly reduce or eliminate actual exposures that may have otherwise occurred during training.

D.2 ACOUSTIC SOURCES

The acoustic sources employed in the NWTRC are categorized as either broadband (producing sound over a wide frequency band) or narrowband (producing sound over a frequency band that that is small in comparison to the center frequency). In general, the narrowband sources in this exercise are Anti-

Submarine Warfare (ASW) sonars and the broadband sources are explosives. This delineation of source types has a couple of implications. First, the transmission loss used to determine the impact ranges of narrowband ASW sonars can be adequately characterized by model estimates at a single frequency. Broadband explosives, on the other hand, produce significant acoustic energy across several frequency decades of bandwidth. Propagation loss is sufficiently sensitive to frequency as to require model estimates at several frequencies over such a wide band.

Second, the types of sources have different sets of harassment metrics and thresholds. Energy metrics are defined for both types. However, explosives are impulsive sources that produce a shock wave that dictates additional pressure-related metrics (peak pressure and positive impulse). Detailed descriptions of both types of sources are provided in the following subsections.

D.2.1 Sonars

Operations in the NWTRC involve five types of narrowband sonars. Harassment estimates are calculated for each sonar according to the manner in which it operates. For example, the SQS-53C is a hull-mounted, surface ship sonar that operates for many hours at a time, so it is useful to calculate and report SQS-53C 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 AN/SSQ-62 is a sonobuoy that is dropped into the water from an aircraft or helicopter and pings about 10 to 30 times in an hour. For the AN/SSQ-62, it is most helpful to calculate and report exposures per sonobuoy. For the MK-48 torpedo, the sonar is modeled for a typical training event and the MK-48 reporting metric is the number of torpedo runs. Table D-2 presents the deploying platform, frequency class, and the reporting metrics for each narrow-band sonar used in the NWTRC.

Table D-2. Active Sonars Employed in NWTRC

Sonar	Description	Frequency Class	Exposures Reported	Units per Hour
MK-48	Torpedo sonar	High-frequency	Per torpedo	One torpedo run
AN/SQS-53C	Surface ship sonar	Mid-frequency	Per hour	120 sonar pings
AN/SQS-56	Surface ship sonar	Mid-frequency	Per hour	120 sonar pings
AN/SSQ-62	Sonobuoy sonar	Mid-frequency	Per sonobuoy	8 sonobuoys
AN/AQS-22	Helicopter-dipping sonar	Mid-frequency	Per dip	2 dips
AN/BQS-15	Submarine sonar	High-frequency	Not modeled	Not modeled

Note that MK-48 source described here is the active pinger on the torpedo; the explosive source of the detonating torpedo is described in the next subsection.

The acoustic modeling that is necessary to support the harassment estimates for each of these sonars relies on a generalized description of the manner of the sonar's operating modes. This description includes the following:

- "Effective" energy source level—This is the level relative to 1 μPa^2-s of the integral over frequency and time of the square of the pressure and is given by the total energy level across the band of the source, scaled by the pulse length (10 $\log_{10}$ [pulse length]).
- Source depth—Depth of the source in meters.
- Nominal frequency—Typically the center band of the source emission. These are frequencies that have been reported in open literature and are used to avoid classification issues.

Differences between these nominal values and actual source frequencies are small enough to be of little consequence to the output impact volumes.

- Source directivity—The source beam is modeled as the product of a horizontal beam pattern and a vertical beam pattern. Two parameters define the horizontal beam pattern:
  - Horizontal beam width—Width of the source beam (degrees) in the horizontal plane (assumed constant for all horizontal steer directions).
  - Horizontal steer direction—Direction in the horizontal in which the beam is steered relative to the direction in which the platform is heading.

  The horizontal beam is assumed to have constant level across the width of the beam with flat, 20-dB down sidelobes at all other angles.

  Similarly, two parameters define the vertical beam pattern:

  - Vertical beam width—Width of the source beam (degrees) in the vertical plane measured at the 3-dB down point (assumed constant for all vertical steer directions).
  - Vertical steer direction—Direction in the vertical plane that the beam is steered relative to the horizontal (upward looking angles are positive).

  To avoid sharp transitions that a rectangular beam might introduce, the power response at vertical angle 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, 3 knots). For stationary (or nearly stationary) sources, the "average" speed of the animal is used in place of the platform speed. The attendant assumption is that the animals are all moving in the same constant direction.

Many of the actual parameters and capabilities of these sonars are classified. Parameters used for modeling were derived to be as representative as possible taking into account the manner with which the sonar would be used in various training scenarios. However, when there was a wide range of potential modeling input values, the default was to model using a nominal parameter likely to result in the most impact, so that the model would err towards the maximum potential exposures.

For the sources that are essentially stationary (AN/SSQ-62 and AN/AQS-22), emission spacing is the product of the ping cycle time and the average animal speed.

D.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 NWTRC there are three types of explosive sources: AN/SSQ-110 Extended Echo Ranging (EER) sonobuoys, demolition charges, and munitions (MK-48 torpedo, Maverick, Harpoon, HARM, HELLFIRE and SLAM missiles, MK-82, MK-83, MK-84, GBU-10, GBU-12 and GBU-16 bombs, 5-inch rounds and 76 mm gunnery rounds). The EER source can be detonated at several depths within the water column. For this analysis a relatively shallow depth of 20 meters is used to optimize the likelihood of the source being positioned in a surface duct. Demolition charges are typically modeled as detonating near the bottom. For a SINKEX the demolition charge would be on the hull. The MK-48 detonates immediately below the hull of its target (nominally 50 feet). A source depth of 2 meters is used for bombs and missiles that do not strike their target. For the gunnery rounds, a source depth of 1 foot is used. The NEWs for these sources are as follows:

- EER Source—5 pounds
- Demolition charge—10 pounds in Explosive Ordnance Disposal (EOD), 100 pounds in a sinking exercise (SINKEX)
- MK-48—851 pounds
- Maverick—78.5 pounds
- Harpoon—448 pounds
- HARM—41.6 pounds
- HELLFIRE—16.4 pounds
- SLAM—164.25 pounds
- MK-82—238 pounds
- GBU-10—945 pounds
- GBU-12—238 pounds
- GBU-16—445 pounds
- 5-inch rounds—9.54 pounds
- 76 mm rounds—1.6 pounds

The exposures 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. There may be rare occasions when MSEs are part of a static location event. For these events, the Churchill FEIS approach was extended to cover events occurring at the same location. For MSE exposures, accumulated energy over the entire training time is the natural extension for energy thresholds since energy accumulates with each subsequent shot; this is consistent with the treatment of multiple arrivals in Churchill. For positive impulse, it is consistent with the Churchill FEIS to use the maximum value over all impulses received.

For MSEs, the acoustic criterion for sub-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.

A special case in which simple addition of the harassment estimates may not be appropriate is addressed by the modeling of a "representative" SINKEX. In a SINKEX, a decommissioned surface ship is towed to a specified deep-water location and there used as a target for a variety of weapons. Although no two SINKEXs are ever the same, a representative case derived from past exercises is described in the *Programmatic SINKEX Overseas Environmental Assessment* (March 2006) for the Western North Atlantic.

In a SINKEX, weapons are typically fired in order of decreasing range from the source, with weapons fired until the target is sunk. A torpedo is used after all munitions have been expended if the target is still afloat. Since the target may sink at any time during the exercise, the actual number of weapons used can vary widely. In the representative case, however, all of the ordnances are assumed expended; this represents the worst case with maximum exposure. The sequence of weapons firing for the representative SINKEX is described in Table D-3.

Table D-3. Representative SINKEX Weapons Firing Sequence

Time (Local)	Event Description
0900	Range Control Officer receives reports that the exercise area is clear of non-participant ship traffic, marine mammals, and sea turtles.
0910	2 HARM missiles fired, both hit target (5 minutes apart).
0925	3 Harpoon missiles fired, all hit target (1 minute apart).
0945	1 SLAM-ER missile fired, hits target.
1030	Surface gunfire commences – 500 five-inch rounds fired (one every 6 seconds), 350 hit target, 150 miss target. 200 76-mm rounds fired, 140 hit target, 60 miss.
1200	1 Hellfire missile fired, hits target.
1230	3 Maverick missiles fired, 2 hit target, 1 misses (5 minutes apart).
1330	4 live GBU-12 bombs dropped – 3 hit target, 1 misses target (2 minutes apart). 4 live GBU-16 bombs dropped – 3 hit target, 1 misses target (2 minutes apart). 4 live GBU-10 bombs dropped – 3 hit target, 1 misses target (2 minutes apart).
1500	MK 48 Torpedo fired, hits, and does not sink target.
1700	Underwater demolition to sink target.

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.

D.3 ENVIRONMENTAL PROVINCES

Propagation loss ultimately determines the extent of the Zone of Influence (ZOI) for a particular source activity. In turn, propagation loss as a function of range responds to a number of environmental parameters:

- Water depth
- Sound speed variability throughout the water column

- Bottom geo-acoustic properties, and
- Surface roughness, as determined by wind speed

Due to the importance that propagation loss plays in ASW, the Navy has, over the last four to five decades, invested heavily in measuring and modeling these environmental parameters. The result of this effort is the following collection of global databases of these environmental parameters, which are accepted as standards for Navy modeling efforts.

- Water depth—Digital Bathymetry Data Base Variable Resolution (DBDBV)
- Sound speed—Generalized Digital Environmental Model (GDEM)
- Bottom loss—Low-Frequency Bottom Loss (LFBL), Sediment Thickness Database, and High-Frequency Bottom Loss (HFBL), and
- Wind speed—U.S. Navy Marine Climatic Atlas of the World

This section provides a discussion of the relative impact of these various environmental parameters. These examples then are used as guidance for determining environmental provinces (that is, regions in which the environmental parameters are relatively homogeneous and can be represented by a single set of environmental parameters) within the NWTRC.

D.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 on the ZOI calculations. Bottom loss can also vary considerably over typical operating areas, but its impact on ZOI calculations tends to be limited to waters on the continental shelf and the upper portion of the slope. Generally, the primary propagation paths in deep water, from the source to most of the ZOI volume, do not involve any interaction with bottom. In shallow water, particularly if the sound velocity profile directs all propagation paths to interact with the bottom, bottom loss variability can play a larger role.

The spatial variability of the sound speed field is generally small over operating areas of typical size. The presence of a strong oceanographic front is a noteworthy exception to this rule. To a lesser extent, variability in the depth and strength of a surface duct can be of some importance. In the mid-latitudes, seasonal variation often provides the most significant variation in the sound speed field. For this reason, both summer and winter profiles are modeled for each selected environment.

D.3.2 Environmental Provincing Methodology

The underwater acoustic environment can be quite variable over ranges in excess of 10 kilometers (km). For ASW applications, ranges of interest are often sufficiently large as to warrant the modeling of the spatial variability of the environment. In the propagation loss calculations, each of the environmental parameters is allowed to vary (either continuously or discretely) along the path from acoustic source to receiver. In such applications, each propagation loss calculation is conditioned upon the particular locations of the source and receiver.

On the other hand, the range of interest for marine animal harassment by most Naval activities is more limited. This reduces the importance of the exact location of source and marine animal and makes the modeling required more manageable in scope.

In lieu of trying to model every environmental profile that can be encountered in an operating area, this effort utilizes a limited set of representative environments. Each environment is characterized by a fixed water depth, sound velocity profile, and bottom loss type. The operating area is then partitioned into homogeneous regions (or provinces), and the most appropriately representative environment is assigned to each. This process is aided by some initial provincing of the individual environmental parameters. The

Navy-standard high-frequency bottom loss database in its native form is globally partitioned into nine classes. Low-frequency bottom loss is likewise provinced in its native form, although it is not considered in the process of selecting environmental provinces. Only the broadband sources produce acoustic energy at the frequencies of interest for low-frequency bottom loss (typically less than 1 kHz); even for those sources the low-frequency acoustic energy is secondary to the energy above 1 kHz. The Navy-standard sound velocity profiles database is also available as a provinced subset. Only the Navy-standard bathymetry database varies continuously over the world’s oceans. However, even this environmental parameter is easily provinced by selecting a finite set of water depth intervals. For this analysis “octave-spaced” intervals (10, 20, 50, 100, 200, 500, 1,000, 2,000, and 5,000 meters) 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.

D.3.3 Description of Environmental Provinces

The NWTRC encompasses a large area off the U.S. West Coast. For this analysis, the general operating area is bounded to the north and south by 48^{o} 30’ N and 40^{o} N and to the west by meridian of 130^{o} W and to the east by land. Within this large region a sub-area used for SINKEX operations is defined by the following additional restrictions:

- More than 50 nautical miles (nm) from land, and
- Water depth greater than 1,000 fathoms (1,852 meters).

Some of the active sonars are limited to Warning Area 237 (W-237), an irregularly-shaped region with the following vertices:

48^{o} 21’ 03” N 130^{o} 00’ 00” W

48^{o} 20’ 00” N 128o 00’ 00” W

48o 08’ 59” N 125o 55’ 00” W

46o 32’ 00” N 126o 42’ 00” W

45o 50’ 00” N 128^{o} 10’ 00” W

The surface ship sonars are deployed throughout the general operating area. The air-deployed sonars, including the AN/SSQ-110, are limited to W-237. The explosive sources and demolition charges are limited to the SINKEX subarea.

This subsection describes the representative environmental provinces selected for the NWTRC. For all of these provinces, the average winter wind speed is 14 knots, whereas the average summer wind speed is 8 knots.

The general operating area of the NWTRC contains a total of 47 distinct environmental provinces. These represent various combinations of nine bathymetry provinces, four Sound Velocity Profile (SVP) provinces, and six HFBL classes. Among these 47 provinces, some share important characteristics while others occur infrequently, so the provinces were reduced to a generalized class of 16 fundamental provinces.

The bathymetry provinces represent depths ranging from very shallow to typical deep-water depths. However, nearly 90% of the NWTRC is characterized as deep-water (depths of 1,000 meters or more). The distribution of the bathymetry provinces over the NWTRC is provided in Table D-4.

Four SVP provinces describe the sound speed field in the NWTRC; however, only two (provinces 30 and 35) make any significant contribution to the analysis. The variability among the four provinces is relatively small as demonstrated by the summer profiles presented in Figure D-1. The dominant difference among the profiles is the relative strength of a suppressed secondary sound channel. This feature is most clearly in the two dominant provinces.

Table D-4. Distribution of Bathymetry Provinces in NWTRC

Province Depth (m)	Frequency of Occurrence
10	0.32 %
20	0.68 %
50	2.24 %
100	3.71 %
200	3.12 %
500	3.00 %
1,000	4.55 %
2,000	55.48 %
5,000	26.90 %

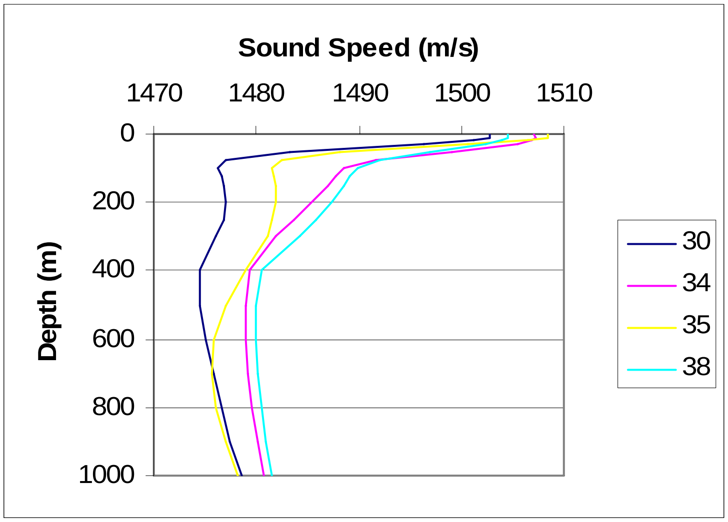


Figure D-1. Summer SVPs in NWTRC

The variation in the winter SVPs among the provinces is a bit more pronounced (Figure D-2). All four provinces display a surface duct but the two dominant provinces have a much deeper mixed layer (as much as 350 meters). This feature provides an efficient propagation channel when source and receiver are both located above the mixed layer.

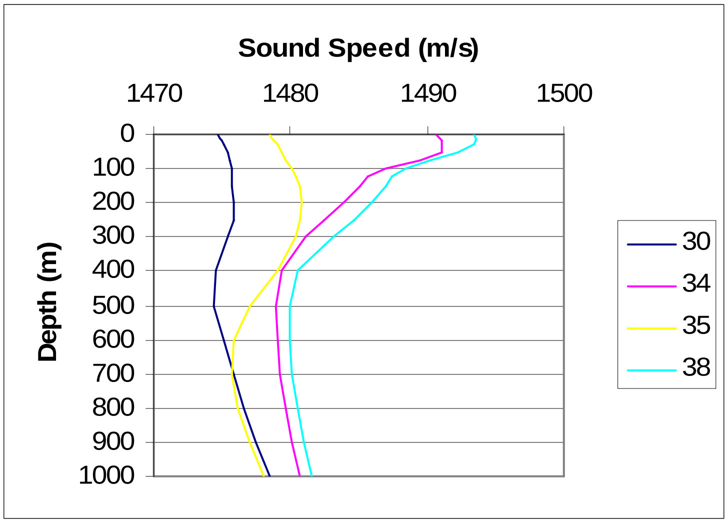


Figure D-2. Winter SVPs in NWTRC

The distribution of the SVP provinces across the NWTRC is provided in Table D-5.

Table D-5. Distribution of SVP Provinces in NWTRC

SVP Province	Frequency of Occurrence
30	87.39 %
34	0.78 %
35	11.53 %
38	0.30 %

The six HFBL classes represented in the NWTRC range from low-loss bottoms (class 2 and 3) to high-loss bottoms (classes 7 and 8). The distribution of HFBL classes summarized in Table D-6 indicates that both low- and high-loss classes are approximately equally distributed.

Table D-6. Distribution of High-Frequency Bottom Loss Classes in NWTRC

HFBL Class	Frequency of Occurrence
2	23.60 %
3	6.15 %
4	21.79 %
6	18.20 %
7	2.26 %
8	28.00 %

The logic for consolidating the environmental provinces focuses on 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 nine bathymetry provinces are represented. Then within each bathymetry province further partitioning of provinces proceeded as follows:

- The four shallowest bathymetry provinces are each represented by one environmental province. In each case, the bathymetry province is dominated by a single, low-loss bottom, so that the secondary differentiating environmental parameter is of no consequence.
- The 200- and 500-meter bathymetry provinces each consist of two environmental provinces in order to reflect both low- and high-loss bottoms that are prevalent at these depths. The 1,000-meter bathymetry province includes only high-loss bottoms and therefore does not need to be partitioned
- The 2,000-meter bathymetry province contains negligible variability in sound speed profiles. However, the 2,000-meter bathymetry province is significantly large as to warrant some partitioning based upon bottom loss. This bathymetry province is subdivided into three environmental provinces using HFBL classes 4, 6 and 8.
- The 5,000-meter bathymetry province is also a prevalent water depth in the NWTRC. For this analysis, it is partitioned into four environment provinces to capture both SVP province (30 and 35), and bottoms that are low-loss (HFBL classes 2 and 3) and high-loss (HFBL class 7).

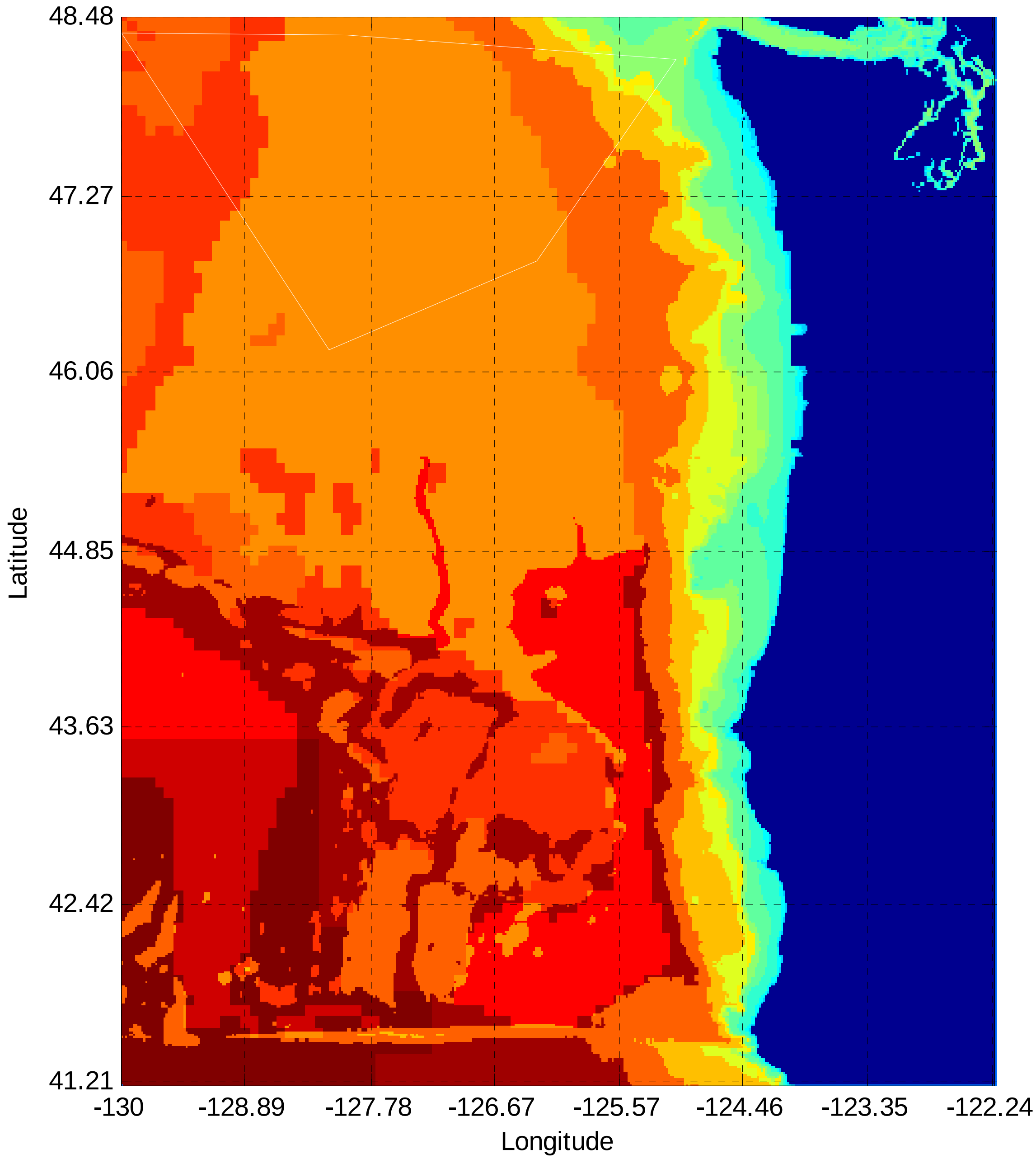
The resulting 16 environmental provinces used in the NWTRC acoustic modeling are described in Table D-7.

The percentages given in the preceding table indicate the frequency of occurrence of each environmental province across the general operating area in the NWTRC. Geographically, the distribution of these 16 environmental provinces is exhibited in Figure D-3.

Table D-7. Distribution of Environmental Provinces in General OPAREA of NWTRC

Environmental Province	Water Depth	SVP Province	HFBL Class	LFBL Province	Sediment Thickness	Frequency of Occurrence
1	10 m	30	2	0	0.2 secs	0.324%
2	20 m	30	2	0	0.2 secs	0.688%
3	50 m	30	2	0	0.27 secs	2.268%
4	100 m	30	2	– 10	0.41 secs	3.751%
5	200 m	30	2	– 10*	0.33 secs	2.577%
6	200 m	30	8	– 10*	0.62 secs	0.582%
7	500 m	30	8	14	0.31 secs	2.484%
8	500 m	30	2	– 10	0.23 secs	0.550%
9	1,000 m	30	8	14	0.21 secs	4.605%
10	2,000 m	30	4	18	0.82 secs	29.627%
11	2,000 m	30	8	18	0.41 secs	15.460%
12	2,000 m	30	6	19	0.2 secs	11.026%
13	5,000 m	30	2	14	0.74 secs	8.396%
14	5,000 m	35	3	18	0.36 secs	3.960%
15	5,000 m	30	7	14	0.88 secs	7.815%
16	5,000 m	35	7	18	0.29 secs	5.886%

* Negative province numbers indicate shallow water provinces



Note: the northwestern coast of the United States is in blue, and higher province index numbers correspond to redder colors. The white polygon represents W-237.

Figure D-3. NWTRC Environmental Provinces over OPAREA

The distribution of the environments within the SINKEX area is, by definition, limited to the two deepest bathymetry provinces as indicated in Table D-8.

Table D-8. Distribution of Environmental Provinces within SINKEX Area

Environmental Province	Frequency of Occurrence
10	38.48 %
11	13.92 %
12	14.21 %
13	9.67 %
14	5.13 %
15	9.19 %
16	9.40 %

The air-deployed sonars are also restricted in their use. They are limited to W-237 for which the distribution of provinces is provided in Table D-9.

Table D-9. Distribution of Environmental Provinces within W-237

Environmental Province	Frequency of Occurrence
5	1.112 %
6	0/015 %
7	0.846 %
8	0.395 %
9	3.111 %
10	71.883 %
11	7.976 %
12	14.662 %

D.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 (EFD, 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 is the accumulated (summed over all source emissions) EFD received by the animal over the duration of the activity. Harassment measures for explosive sources include EFD 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 exposures is estimated as the “product” (scalar or vector, depending on whether an animal density depth profile is available) of the impact volume and the animal densities.

This section describes in detail the process of computing impact volumes (that is, the first four steps described above). This discussion is presented in two parts: active sonars and explosive sources. The relevant assumptions associated with this approach and the limitations that are implied are also presented. The final step, computing the number of exposures, is discussed in subsection D.5.

D.4.1 Computing Impact Volumes for Active Sonars

This section provides a detailed description of the approach taken to compute impact volumes for active sonars. Included in this discussion are:

- Identification of the underwater propagation model used to compute transmission loss data, a listing of the source-related inputs to that model, and a description of the output parameters that are passed to the energy accumulation algorithm.
- Definitions of the parameters describing each sonar type.

Description of the algorithms and sampling rates associated with the energy accumulation algorithm.

D.4.1.1 Transmission Loss Calculations

TL data are pre-computed for each of two seasons in each of the environmental provinces described in the previous subsection using the GRAB propagation loss model (Keenan, 2000). The TL output consists of a parametric description of each significant eigenray (or propagation path) from source to animal. The description of each eigenray includes the departure angle from the source (used to model the source vertical directivity later in this process), the propagation time from the source to the animal (used to make corrections to absorption loss for minor differences in frequency and to incorporate a surface-image interference correction at low frequencies), and the TL suffered along the eigenray path.

The eigenray data for a single GRAB model run are sampled at uniform increments in range out to a maximum range for a specific "animal" (or "target" in GRAB terminology) depth. Multiple GRAB runs are made to sample the animal depth dependence. The depth and range sampling parameters are summarized in Table D-10. Note that some of the low-power sources do not require TL data to large maximum ranges.

Table D-10. TL Depth and Range Sampling Parameters by Sonar Type

Sonar	Range Step	Maximum Range	Depth Sampling
MK-48	10 m	10 km	0 – 1 km in 5-m steps 1 km – Bottom in 10-m steps
AN/SQS-53C	10 m	200 km	0 – 1 km in 5-m steps 1 km – Bottom in 10-m steps
AN/AQS-22	10 m	10 km	0 – 1 km in 5-m steps 1 km – Bottom in 10-m steps
AN/ASQ-62	5 m	5 km	0 – 1 km in 5-m steps 1 km – Bottom in 10-m steps
AN/SQS-56	10 m	50 km	0 – 1 km in 5-m steps 1 km – Bottom in 10-m steps

In a few cases, most notably the AN/SQS-53C for thresholds below approximately 180 dB, TL data may be required by the energy summation algorithm at ranges greater than covered by the pre-computed GRAB data. In these cases, TL is extrapolated to the required range using a simple cylindrical spreading loss law in addition to the appropriate absorption loss. This extrapolation leads to a conservative (or under) estimate of TL at the greater ranges.

Although GRAB provides the option of including the effect of source directivity in its eigenray output, this capability is not exercised. By preserving data at the eigenray level, this allows source directivity to be applied later in the process and results in fewer TL calculations.

The other important feature that storing eigenray data supports is the ability to model the effects of surface-image interference that persist over range. However, this is primarily important at frequencies lower than those associated with the sonars considered in this subsection. A detailed description of the modeling of surface-image interference is presented in the subsection on explosive sources.

D.4.1.2 Energy Summation

The summation of EFD over multiple pings in a range-independent environment is a trivial exercise for the most part. A volumetric grid that covers the waters in and around the area of sonar operation is initialized. The source then begins its set of pings. For the first ping, the TL from the source to each grid point is determined (summing the appropriate eigenrays after they have been modified by the vertical beam pattern), the “effective” energy source level is reduced by that TL, and the result is added to the accumulated EFD at that grid point. After each grid point has been updated, the accumulated energy at grid points in each depth layer is compared to the specified threshold. If the accumulated energy exceeds that threshold, then the incremental volume represented by that grid point is added to the impact volume for that depth layer. Once all grid points have been processed, the resulting sum of the incremental volumes represents the impact volume for one ping.

The source is then moved along one of the axes in the horizontal plane by the specified ping separation range and the second ping is processed in a similar fashion. Again, once all grid points have been processed, the resulting sum of the incremental volumes represents the impact volume for two pings. This procedure continues until the maximum number of pings specified has been reached.

Defining the volumetric grid over which energy is accumulated is the trickiest aspect of this procedure. The volume must be large enough to contain all volumetric cells for which the accumulated energy is likely to exceed the threshold but not so large as to make the energy accumulation computationally unmanageable.

Determining the size of the volumetric grid begins with an iterative process to determine the lateral extent to be considered. Unless otherwise noted, throughout this process the source is treated as omnidirectional 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 (Rmax) for a single ping. The impact range in this case is the maximum range at which the effective energy source level reduced by the TL is greater than the threshold. Next, the source is moved along a straight-line track and EFD is accumulated at a point that has a closest point of approach (CPA) range of RMAX at the mid-point of the source track. That total EFD summed over all pings is then compared to the prescribed threshold. If it is greater than the threshold (which, for the first R_{max}, it must be) then R_{max} is increased by 10 percent, the accumulation process is repeated, and the total energy is again compared to the threshold. This continues until R_{max} grows large enough to ensure that the accumulated EFD at that lateral range is less than the threshold. The lateral range dimension of the volumetric grid is then set at twice R_{max}, with the grid centered along the source track. In the direction of advance for the source, the volumetric grid extends 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 D-4.

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 D-5.

Once the extent of the grid is established, the grid sampling can be defined. In both dimensions of the horizontal plane the sampling rate is approximately $R_{max}/100$. The round-off error associated with this sampling rate is roughly equivalent to the error in a numerical integration to determine the area of a circle with a radius of R_{max} with a partitioning rate of $R_{max}/100$ (approximately 1 percent). The depth-sampling rate of the grid is comparable to the sampling rates in the horizontal plane but discretized to match an actual TL sampling depth. The depth-sampling rate is also limited to no more than 10 meters to ensure that significant TL variability over depth is captured.

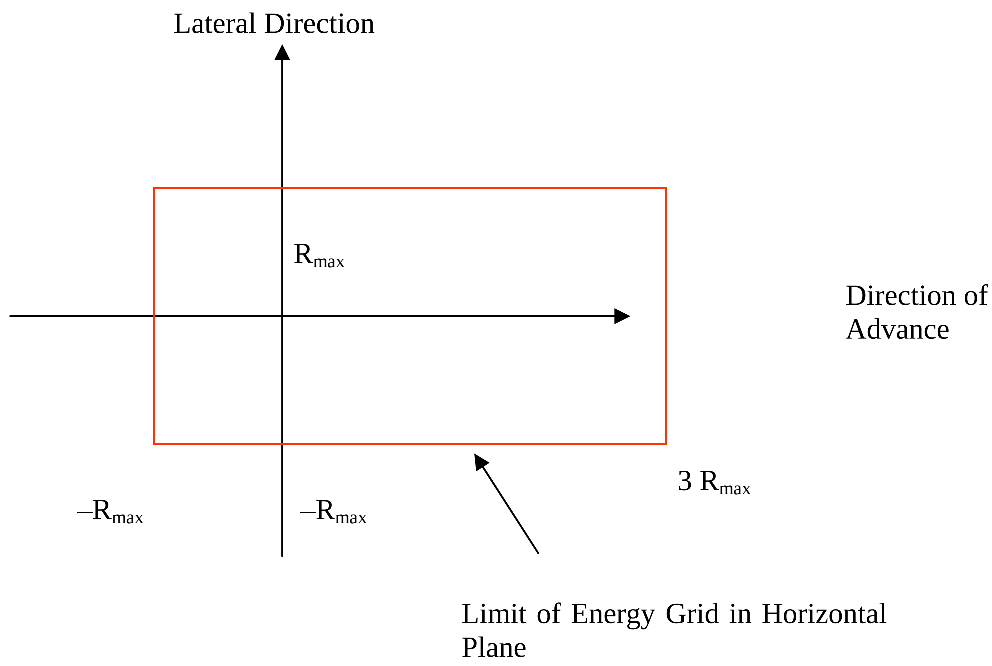


Figure D-4. Horizontal Plane of Volumetric Grid for Omni Directional Source

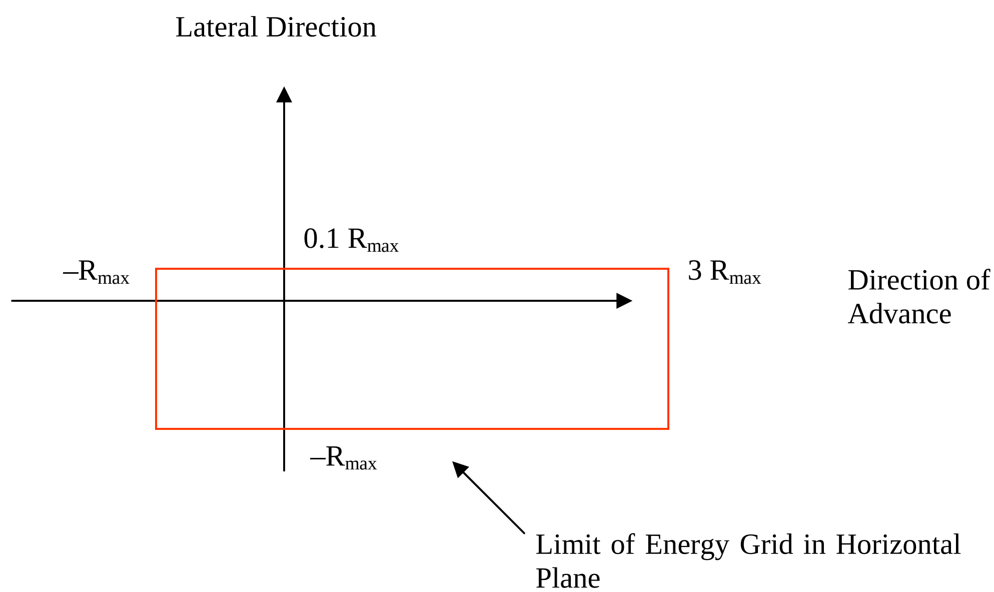


Figure D-5. Horizontal Plane of Volumetric Grid for Starboard Beam Source

D.4.1.3 Impact Volume per Hour of Sonar Operation

The impact volume for a sonar moving relative to the animal population increases with each additional ping. The rate at which the impact volume increases varies with a number of parameters but eventually approaches some asymptotic limit. Beyond that point the increase in impact volume becomes essentially linear as depicted in Figure D-6.

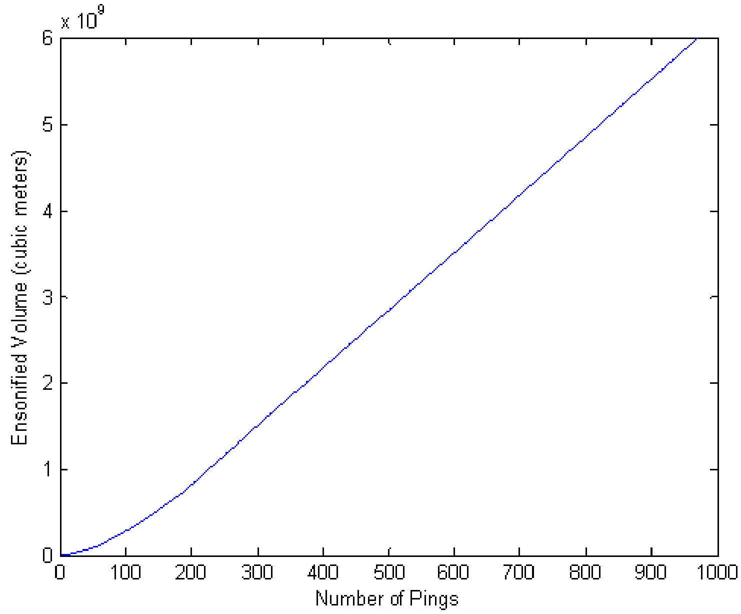


Figure D-6. 53C Impact Volume by Ping

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 D-7 provides an example of an hourly impact volume vector for a particular environment.

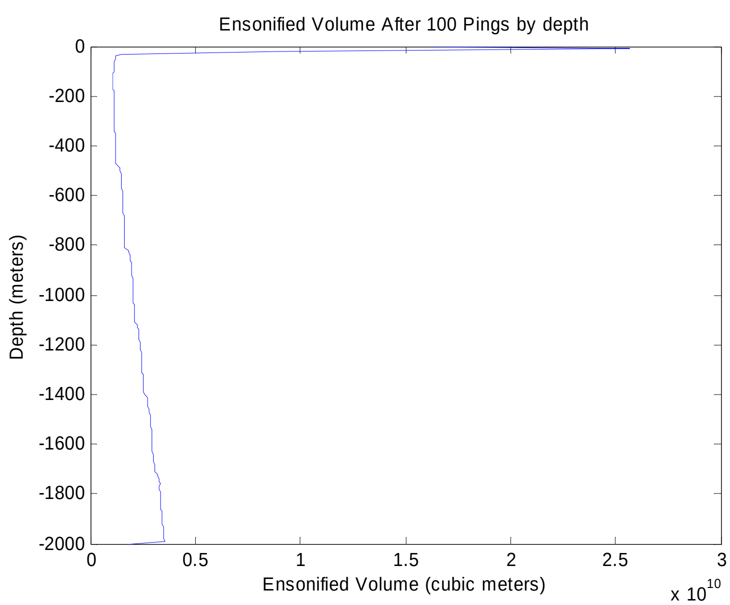


Figure D-7. Example of an Impact Volume Vector

D.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 D.4.2.3.

D.4.2.1 Transmission Loss Calculations

Modeling impact volumes for explosive sources span requires the same type of TL data as needed for active sonars. However, unlike active sonars, explosive ordnances and the EER source are broadband, contributing significant energy from tens of hertz to tens of kilohertz. To accommodate the broadband nature of these sources, TL data are sampled at seven frequencies from 10 Hz to 40 kHz, spaced every two octaves.

An important propagation consideration at low frequencies is the effect of surface-image interference. As either source or target approach the surface, pairs of paths that differ by a single surface reflection set up an interference pattern that ultimately causes the two paths to cancel each other when the source or target is at the surface. A fully coherent summation of the eigenrays produces such a result but also introduces extreme fluctuations that would have to be highly sampled in range and depth, and then smoothed to give meaningful results. An alternative approach is to implement what is sometimes called a semi-coherent summation. A semi-coherent sum attempts to capture significant effects of surface-image interference (namely the reduction of the field due to destructive interference of reflected paths as the source or target approach the surface) without having to deal with the more rapid fluctuations associated with a fully coherent sum. The semi-coherent sum is formed by a random phase addition of paths that have already been multiplied by the expression:

$$\sin^2 [\, 4 \pi f z_s z_a / (c^2 t) \,]$$

where f is the frequency, z_s is the source depth, z_a is the animal depth, c is the sound speed and t is the travel time from source to animal along the propagation path. For small arguments of the sine function this expression varies directly as the frequency and the two depths. It is this relationship that causes the propagation field to go to zero as the depths approach the surface or the frequency approaches zero.

This surface-image interference must be applied across the entire bandwidth of the explosive source. The TL field is sampled at several representative frequencies. However, the image-interference correction given above varies substantially over that frequency spacing. To avoid possible under sampling, the image-interference correction is averaged over each frequency interval.

D.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 D.2.2.

The effective energy source level, which is treated as a de facto input for the other sonars, is instead modeled directly for EER and munitions. For both, the energy source level is comparable to the model used for other explosives (Arons [1954], Weston [1960], McGrath [1971], Urick [1983], Christian and Gaspin [1974]). The energy source level over a one-third octave band with a center frequency of f for a source with a net explosive weight of w pounds is given by:

$$\text{ESL} = 10 \log_{10} (0.26\, f\,) + 10 \log_{10} (\, 2\, p_{max}^{\;2} / [1/\theta^2 + 4\, \pi\, f^{\,2}]\,) + 197 \text{ dB}$$

where the peak pressure for the shock wave at 1 meter is defined as

$$p_{max} = 21600\, (w^{1/3} / 3.28\,)^{1.13} \text{ psi} \qquad \text{(E-1)}$$

and the time constant is defined as:

$$\theta = [(0.058)\, (w^{1/3})\, (3.28 / w^{1/3})^{\,0.22}\,] / 1{,}000 \text{ msec} \qquad \text{(E-2)}$$

In contrast to munitions that are modeled as omnidirectional sources, the EER source is a continuous line array that produces a directed source. The EER array consists of two explosive strips that are fired simultaneously from the center of the array. Each strip generates a beam pattern with the steer direction of the main lobe determined by the burn rate. The resulting response of the entire array is a bifurcated beam for frequencies above 200 Hz, while at lower frequencies the two beams tend to merge into one.

Since very short ranges are under consideration, the loss of directivity of the array needs to be accounted for in the near field of the array. This is accomplished by modeling the sound pressure level across the field as the coherent sum of contributions of infinitesimal sources along the array that are delayed according to the burn rate. For example, for frequency f the complex pressure contribution at a depth z and horizontal range x from an infinitesimal source located at a distance z' above the center of the array is

$$p(r,z) = e^{\,i\phi}$$

where

$$\phi = kr' + \alpha z', \text{ and}$$

$$\alpha = 2\,\pi f / c_b$$

with k the acoustic wave number, c_b the burn rate of the explosive ribbon, and r' the slant range from the infinitesimal source to the field point (x,z).

Beam patterns as function of vertical angle are then sampled at various ranges out to a maximum range that is approximately L^2 / 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 D-8 and Figure D-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 D-8 shows the rise of a single main lobe as range increases.

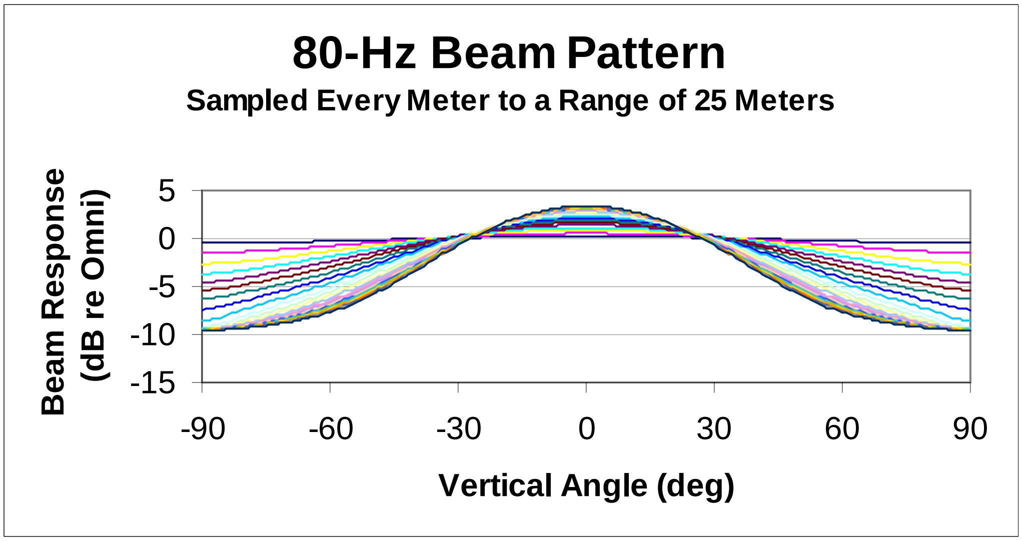


Figure D-8. 80-Hz Beam Patterns across Near Field of EER Source

On the other hand, the 1,250-Hz family of beam patterns depicted in Figure D-9 demonstrates the typical high-frequency bifurcated beam.

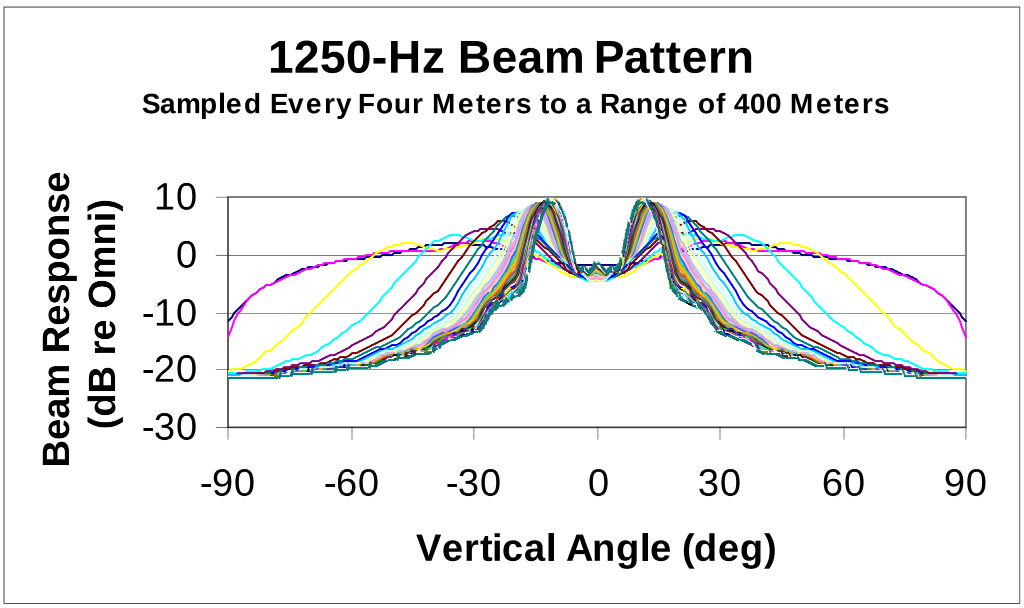


Figure D-9. 1250-Hz Beam Patterns across Near Field of EER Source

D.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.

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 EFD is sampled at several frequencies in one-third-octave bands and only the peak one-third-octave level is accumulated over time.

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 1 meter (given by equation E-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.

“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 1 meter (see, equation B-1), and θ is the time constant defined as

$$\theta = 0.058\, w^{1/3}\, (r/w^{1/3})^{0.22} \text{ seconds}$$

with w the net explosive weight (pounds), and r the slant range between source and animal.

The upper limit of the “partial” impulse integral is

$$T_{min} = \min\,\{T_{cut}, T_{osc}\}$$

where T_{cut} is the time to cutoff and T_{osc} is a function of the animal lung oscillation period. When the upper limit is T_{cut}, the integral is the definition of positive impulse. When the upper limit is defined by T_{osc}, the integral is smaller than the positive impulse and thus is just a “partial” impulse. Switching the integral limit from T_{cut} to T_{osc} accounts for the diminished impact of the positive impulse upon the animals lungs that compress with increasing depth and leads to what is sometimes call a “modified” positive impulse metric.

The time to cutoff is modeled as the difference in travel time between the direct path and the surface-*reflected* path in an isospeed environment. At a range of *r*, the time to cutoff for a source depth z_s and an animal depth z_a is

$$T_{cut} = 1/c \; \{ [r^2 + (z_a + z_s)^2]^{1/2} - [r^2 + (z_a - z_s)^2]^{1/2} \}$$

where *c* is the speed of sound.

The *animal* lung oscillation period is a function of animal mass *M* and depth z_a and is modeled as

$$T_{osc} = 1.17 \, M^{1/3} \, (1 + z_a/33)^{-5/6}$$

where *M* is the animal mass (in kg) and z_a is the animal depth (in feet).

The modified positive impulse threshold is unique among the various injury and harassment metrics in that it is a function of depth and the animal weight. So instead of the user specifying the threshold, it is computed as $K\,(M/42)^{1/3}\,(1 + z_a/33)^{1/2}$. The coefficient *K* depends upon the level of exposure. For the onset of slight lung injury, *K* is 19.7; for the onset of extensive lung hemorrhaging (1% 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.

D.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.

D.4.3 Impact Volume by Region

The NWTRC is described by 16 environmental provinces. The hourly impact volume vector for operations involving any particular source is a linear combination of the 16 impact volume vectors with the weighting determined by the distribution of those 16 environmental provinces within the range. Unique hourly impact volume vectors for winter and summer are calculated for each type of source and each metric/threshold combination.

D.5 RISK FUNCTION: THEORETICAL AND PRACTICAL IMPLEMENTATION

This section discusses the recent addition of a risk function “threshold” to acoustic effects analysis procedure. This approach includes two parts, a new metric, and a function to map exposure level under the new metric to probability of harassment. What these two parts mean, how they affect exposure calculations, and how they are implemented are the objects of discussion.

D.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 micro Pascals) at a given point at time t (in seconds); this function is called a "time series." Figure D-10 gives the time series of the first "hallelujah" in Handel's Hallelujah Chorus.

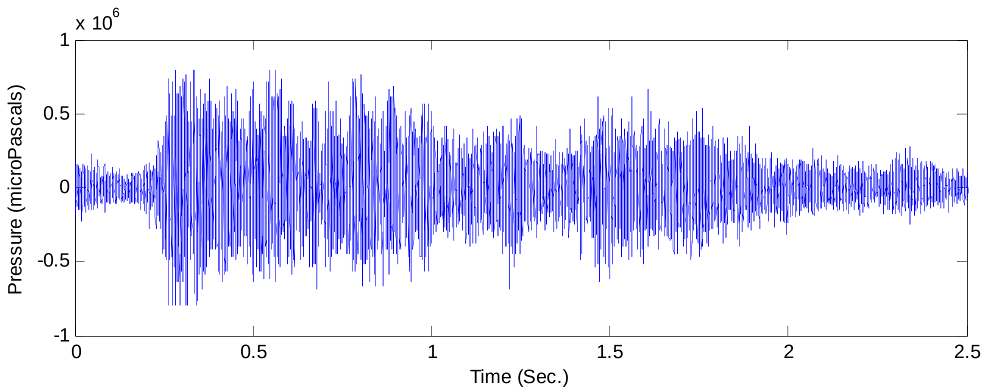


Figure D-10. Time Series

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 location. Let the function $p(t)$, then be expanded to $p(t;x,y,z)$ and denote the time series at point (x,y,z) in space. Thus, the series in Figure D-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 D-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 D-11 is $p^2(t;0,10,-4)$.

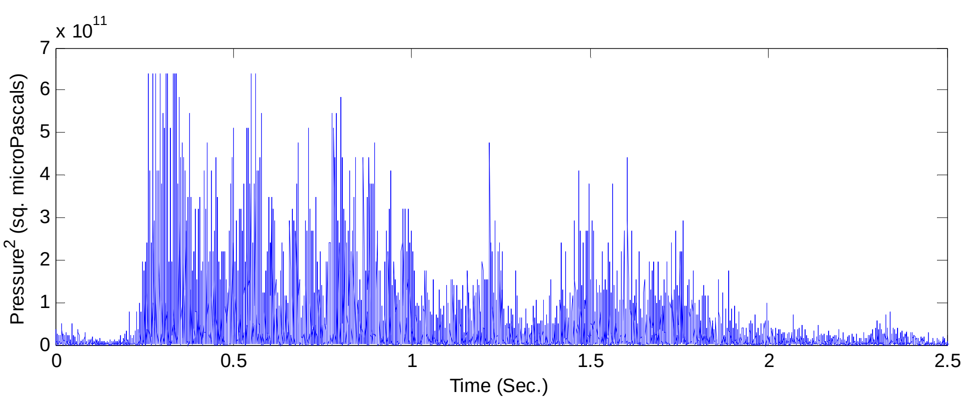


Figure D-11. Time Series Squared

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 D-10, to a single value for each point (*x*,*y*,*z*) in the space. The metric essentially "boils down" the four dimensional *p*(*t*,*x*,*y*,*z*) into a three dimensional function *m*(*x*,*y*,*z*) by dealing with time. There is more than one way to summarize the time component, so there is more than one metric.

D.5.2 Maximum Sound Pressure Level

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 = ρc is the acoustic impedance). This ratio is presented on a logarithmic scale relative to a reference pressure level, and is defined as:

$$SPL = 10\log_{10}\left(\frac{p^2}{p_{ref}^2}\right) = 20\log_{10}\left(abs\left(\frac{p}{p_{ref}}\right)\right)$$

(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 μPa) for 0<*t*<2.5

The $SPL_{\max}$ for this snippet of the Hallelujah Chorus is $10\log_{10}\left(6.4\times10^{11}\,\mu Pa^2/1\mu Pa^2\right) = 118\,dB$ re 1 μPa and occurs at 0.2606 seconds, as shown in Figure D-12.

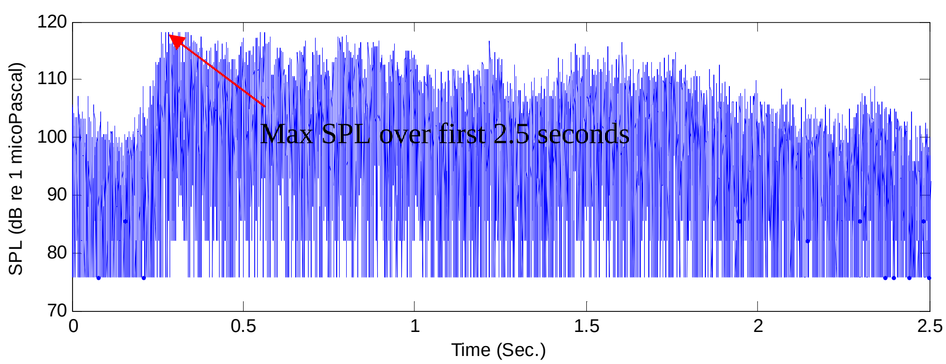


Figure D-12. Max SPL of Time Series Squared

D.5.3 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):

$$EL = 10\log_{10}\left(\frac{\int_0^T p^2(t,x,y,z)dt}{1.0\mu Pa^2 s}\right) = \text{ 109.3 dB re } 1\mu Pa^2 s$$

Energy is sometimes called "equal energy" because if *p*(*t*) is a constant function and the duration is doubled, the effect is the same as doubling the signal amplitude (*y* value). Thus, the duration and the signal have an "equal" influence on the energy metric.

Mathematically,

$$\int_0^{2T} p(t)^2\,dt = 2\int_0^T p(t)^2\,dt = \int_0^T 2\,p(t)^2\,dt$$

or a doubling in duration equals a doubling in energy equals a doubling in signal.

Sometimes, the integration metrics are referred to as having a "3 dB exchange rate" because if the duration is doubled, this integral increases by a factor of two, or 10log10(2)=3.01 dB. Thus, equal energy has "a 3 dB exchange rate."

After p(t) is determined (i.e., when the stimulus is over), propagation models can be used to determine p(t;x,y,z) for every point in the vicinity and for a given metric. Define

$$m_a(x,y,z,T) = \text{value of metric "}a\text{" at point } (x,y,z) \text{ after time } T$$

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.

D.5.3.1 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.

D.5.4 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 its range is the proportion of thresholds.

An example of threshold functions is the heavyside (or unit step) function, currently used to determine PTS and TTS in cetaceans. For PTS, the metric is $m_{energy}(x, y, z)$, defined above, and the threshold function is a heavyside function with a discontinuity at 215 dB, shown in Figure D13.

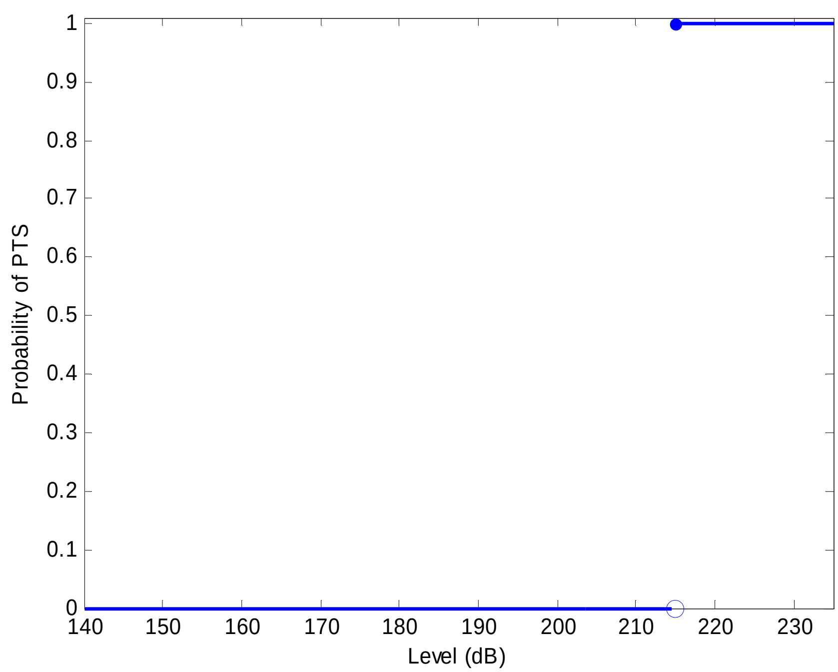


Figure D-13. PTS Heavyside Threshold Function

Mathematically, this D is defined as:

$$D(m_{energy}) = \begin{cases} 0 \ \ for\ m_{energy} < 215 \\ 1 \ \ for\ m_{energy} \geq 215 \end{cases}$$

Any function can be used for D, as long as its range is in [0,1]. The risk function uses 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

$$D(m_{\max SPL}) = \begin{cases} \dfrac{1}{1+\left(\dfrac{K}{m_{\max SPL} - B}\right)^{A}} & for\ m_{\max SPL} \geq B \\ 0 & for\ m_{\max SPL} < B \end{cases}$$

where B=cutoff (or basement), K=the difference in level (dB) between the basement and the median (50% effect) harassment level, and A = the steepness factor. The dose function for odontocetes and pinnipeds uses the parameters:

B = 120 dB,

K = 45 dB, and

A = 10.

The dose 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 CDF function for evaluating expected harassment.

D.5.5 Multiple Metrics and Thresholds

It is possible to have more than one metric, and more than one threshold in a given metric. For example, in this document, humpback whales have two metrics (energy and max SPL), and three thresholds (two for energy, one for max SPL). The energy thresholds are heavyside functions, as described above, with discontinuities at 215 and 195 for PTS and TTS respectively. The max SPL effect is calculated from the Feller risk function for odontocetes defined in the previous section.

D.5.6 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

$$\int_{-\infty}^{0} \rho(z) \int_{-\infty}^{\infty}\int_{-\infty}^{\infty} D(m_{\max SPL}(x,y,z))\, dx\, dy\, dz$$

D.5.7 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 141 dB, which, depending on the environmental specifics, can drive propagation loss calculations and their numerical integration out to more than 100 km.

The first step in the solution is to separate out the *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 1,000 meters in depth and 10-meter steps to 2,000 meters, which is the limit of animal depth in this analysis. The step size for x is 5 meters, and y is sampled with an interval that increases as the distance from the source increases. Mathematically,

$$z \in Z = \{0,5,...1000,1010,...,2000\}$$
$$x \in X = \{0,\pm 5,...,\pm 5k\}$$
$$y \in Y = \left\{0,\pm 5*(1.005)^0,\pm 5*\left[(1.005)^0+(1.005)^1\right],...,\pm 5*\left[\sum_{i=0}^{j}(1.005)^i\right]\right\}$$

for integers *k*, *j*, which depend on the propagation distance for the source. For this analysis, *k* = 20,000 and *j* = 600.

With these steps, $f(z_0)=\int_{-\infty}^{\infty}\int_{-\infty}^{\infty}D(m_{\max SPL}(x,y,z_0))dxdy$ is approximated as

$$\sum_{z\in Y}\sum_{x\in X}D(m_{\max SPL}(x,y,z_0))\Delta x\Delta y$$

where *X*,*Y* are defined as above.

This calculation must be repeated for each $z_0 \in Z$, to build the discrete function *f*(*z*).

With the calculation of *f*(*z*) complete, the integral of its product with $\rho(z)$ must be calculated to complete evaluation of

$$\int_{-\infty}^{\infty}\rho(z)\int_{-\infty}^{\infty}\int_{-\infty}^{\infty}D(m_{\max SPL}(x,y,z))dxdydz=\int_{-\infty}^{0}\rho(z)f(z)dz$$

Since *f*(*z*) is discrete, and $\rho(z)$ can be readily made discrete, $\int_{-\infty}^{0}\rho(z)f(z)dz$ is approximated numerically as $\sum_{z\in Z}\rho(z)f(z)$, a dot product.

D.5.8 Preserving Calculations for Future Use

Calculating *f*(*z*) is the most time-consuming part of the numerical integration, but the most time-consuming portion of the entire process is calculating $m_{\max SPL}(x,y,z)$ over the area range required for the minimum cutoff value (141 dB). The calculations usually require propagation estimates out to over 100 km, and those estimates, with the beam pattern, are used to construct a sound field that extends 200 km x 200 km—40,000 sq km, with a calculation at the steps for every value of *X* and *Y*, defined above. This is repeated for each depth, to a maximum of 2,000 meters.

Saving the entire $m_{\max SPL}$ for each *z* is unrealistic, requiring great amounts of time and disk space. Instead, the different levels in the range of $m_{\max SPL}$ are sorted into 0.5 dB wide bins; the volume of water at each bin level is taken from $m_{\max SPL}$, and associated with its bin. Saving this, the amount of water ensonified at each level, at 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 (dose response curves) are purely a function of level, not location, so this information is sufficient to calculate *f*(*z*).

Applying the dose 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.

D.5.9 Software Detail

The risk function metric uses the cumulative normal probability distribution to determine the probability that an animal is affected by a given SPL. The probability distribution is defined by a low cutoff level (below which the species is not affected), a 50 percent effect level, and a steepness factor. The acoustic quantity of interest is the maximum SPL experienced over multiple pings in a range-independent environment. The procedure for calculating the impact volume at a given depth is relatively simple. In brief, given the SPL of the source and the 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 SPL. 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 sonar energy, one ping, illustrates the computational process in more detail. First, the SPLs 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 SPLs in this grid become the bins in the volume histogram. Figure D-14 shows a volume histogram for a low-power sonar. Level bins are 0.5 dB in width and the depth is 50 meters in an environment with water depth of 100 meters. The oscillatory structure at very low levels is due the flattening of the TL curve at long distances from the source, which magnifies the fluctuations of the TL as a function of range. The “expected” impact volume for a given level at a given depth is calculated by multiplying the volume in each level bin by the dose response probability function at that level. Total expected impact volume for a given depth is the sum of these “expected” volumes. Figure D-5 is an example of the impact volume as a function of depth at a water depth of 100 meters.

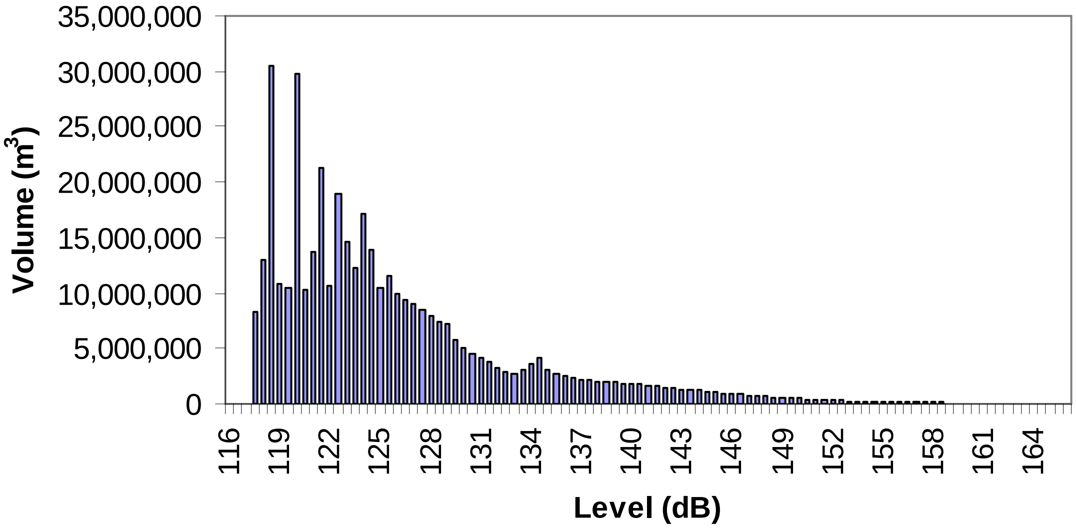


Figure D-14. Example of a Volume Histogram

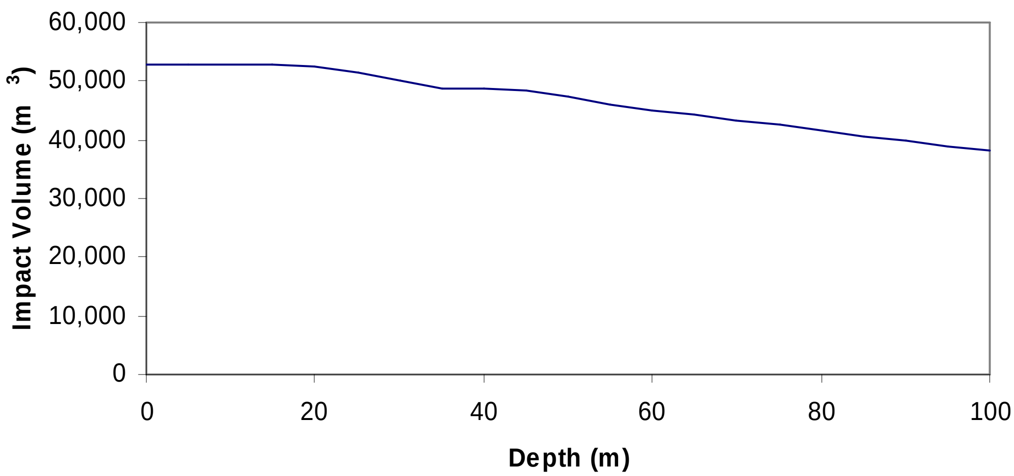


Figure D-15. Example of the Dependence of Impact Volume on Depth

The volumetric grid covers the waters in and around the area of sonar operation. The grid for this analysis has a uniform spacing of 5 meters in the x-coordinate and a slowly expanding spacing in the y-coordinate that starts with 5 meters spacing at the origin. The growth of the grid size along the y-axis is a geometric series 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 1,000 meters and 10 meters from 1,000 to 2,000 meters. This is the same depth mesh used for the effective energy metric as described above. The depth mesh does not extend below 2,000 meters, on the assumption that animals of interest are not found below this depth.

The next three figures indicate how the accuracy of the calculation of impact volume depends on the parameters used to generate the mesh in the horizontal plane. Figure D-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 meters and the *y*-axis growth factor is 0, i.e., uniform spacing. The impact volume for a 5-meter 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 D-17 shows the relative change of impact volume for one ping as a function of the grid size used for the *y*-axis. The *x*-axis grid size is fixed at 5 meters and the *y*-axis growth factor is 0. The impact volume for a 5 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 D-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.

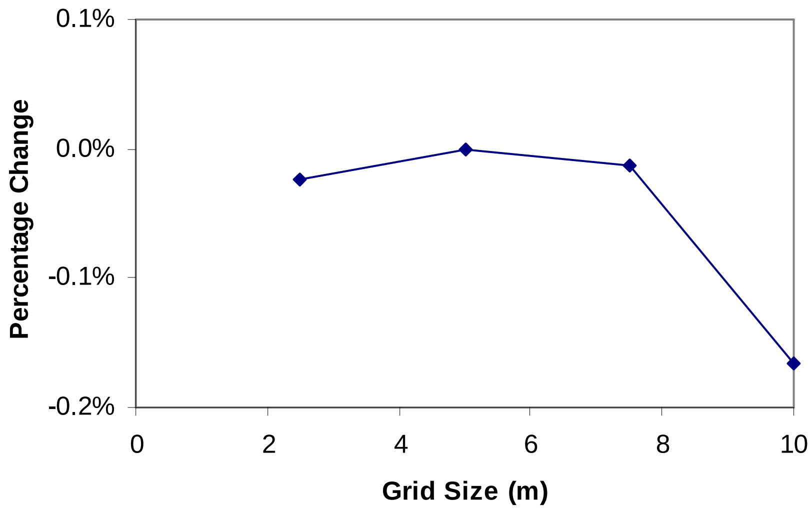


Figure D-16. Change of Impact Volume as a Function of *x*-axis Grid Size

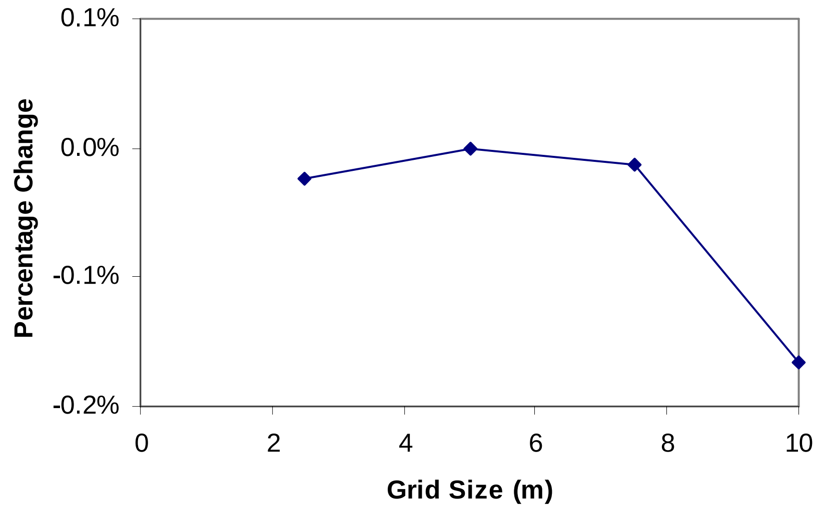


Figure D-17. Change of Impact Volume as a Function of y-axis Grid Size

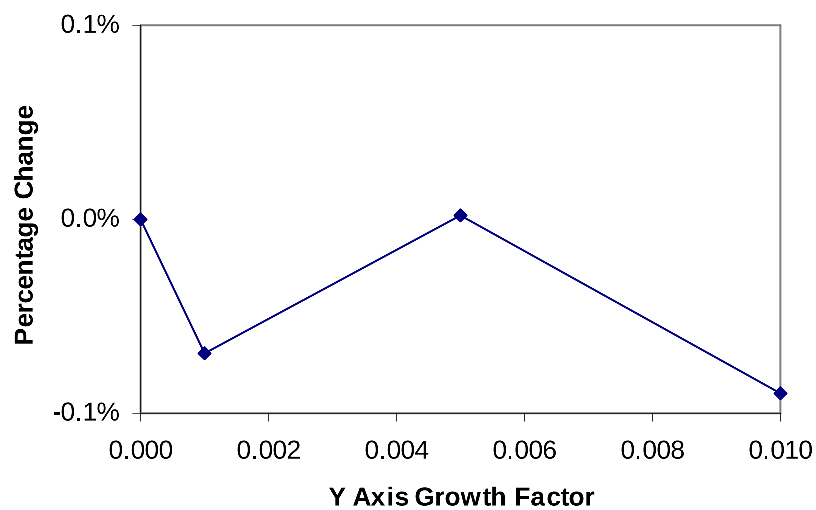


Figure D-18. Change of Impact Volume as a Function of y-axis Growth Factor

Another factor influencing the accuracy of the calculation of impact volumes is the size of the bins used for SPL. The SPL bins extend from 100 dB (far lower than required) up to 300 dB (much higher than that expected for any sonar system). Figure D-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 the initial *y*-axis grid size is 5 meters, and the *y*-axis growth factor is 0.005. The impact volume for a bin size of 0.5 dB is the reference. For bin widths from 0.25 dB to 1.00 dB, the change is about 0.1%. A bin width of 0.5 is used in our calculations.

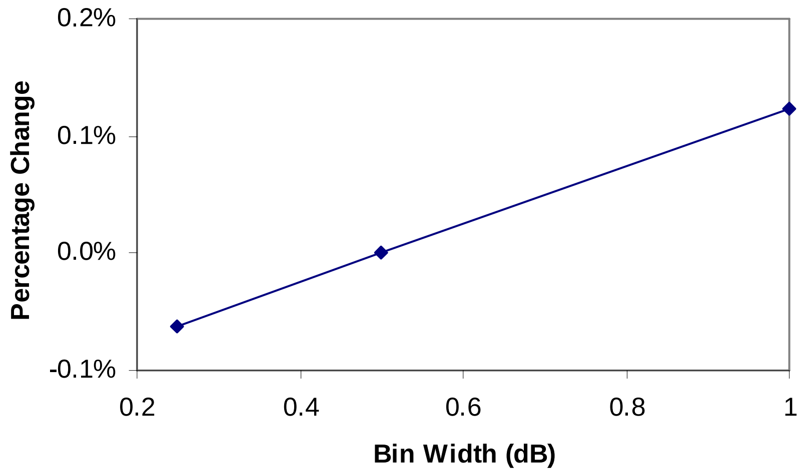


Figure D-19. Change of Impact Volume as a Function of Bin Width

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 1,000 pings. Since energy is accumulated, the same TL can be used for one ping with the source level increased by 30 dB (10 $\log_{10}$(1000)). Reducing the source level by 30 dB, to get back to its original value, permits the handling of an SPL threshold down to 143 dB, comparable to the minimum required. Hence, the TL calculated to support energy accumulation for 1,000 pings will also support calculation of impact volumes for the risk function metric.

The process of obtaining the maximum SPL at each grid point in the volumetric grid is straightforward. The active sonar starts at the origin and moves at constant speed along the positive *x*-axis emitting a burst of energy, a ping, at regularly spaced intervals. For each ping, the distance and horizontal angle connecting the sonar to each grid point is computed. Calculating the TL from the source to a grid point has several steps. The TL is made up of the sum of many eigenrays connecting the source to the grid point. The beam pattern of the source is applied to the eigenrays based on the angle at which they leave the source. After summing the vertically beamformed eigenrays on the range mesh used for the TL calculation, the vertically beamformed TL for the distance from the sonar to the grid point is derived by interpolation. Next, the horizontal beam pattern of the source is applied using the horizontal angle connecting the sonar to the grid point. To avoid problems in extrapolating TL, only grid points with distances less than R_{max} are used. To obtain the SPL at a grid point, the SPL of the source is reduced by that TL. For the first ping, the volumetric grid is populated by the calculated SPL at each grid point. For the second ping and subsequent pings, the source location increments along the x-axis by the spacing between pings and the SPL for each grid point is again calculated for the new source location. Since the risk function metric uses the maximum of the SPLs at each grid point, the newly calculated SPL at each grid point is compared to the SPL stored in the grid. If the new level is larger than the stored level, the value at that grid point is replaced by the new SPL.

For each bin, a volume is determined by summing the ensonified volumes with a maximum SPL in the bin's interval. This forms the volume histogram shown in Figure D-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 D-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 dose response metric is essentially linear with the number of pings. Figure D-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 D-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.

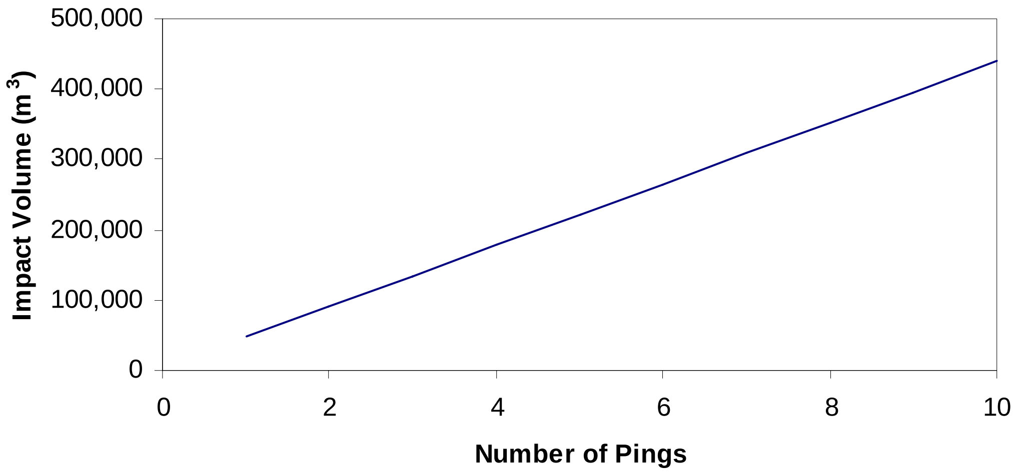


Figure D-20. Dependence of Impact Volume on the Number of Pings

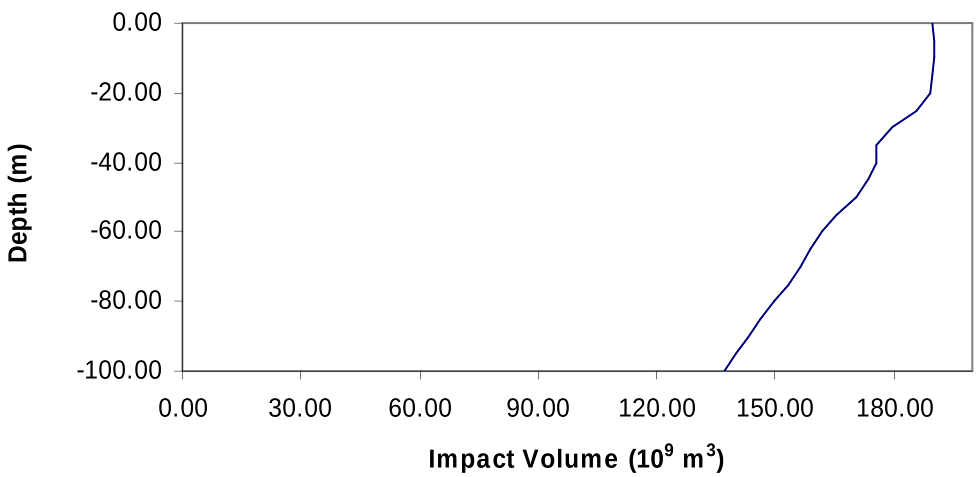


Figure D-21. Example of an Hourly Impact Volume Vector

D.6 EXPOSURE ESTIMATES

Densities are usually reported by marine biologists as animals per square kilometer (km^2), 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

D.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.

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 0.0117 whales per km^2. 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 0.0117*0.31/0.01 = 0.3627 per cubic km, at 10-200 m is 0.0117*0.08/0.19 = 0.004926 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,

- 0.3627 whales per cubic km is used for 0-10 meters,
- 0.004926 whales per cubic km is used for 10-50 meters, and
- 0.004926 whales per cubic km is used for 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 exposure count for each species is the unit operation exposure count multiplied by the number of units (hours, sonobuoys, etc).

D.7 POST ACOUSTIC MODELING ANALYSIS

The acoustic modeling results include additional analysis to account for land mass, multiple ships, and number of animals that could be exposed. Specifically, post modeling analysis is designed to consider:

Acoustic footprints for sonar sources must account for land masses.

Acoustic modeling should account for the maximum number of individuals of a species that could potentially be exposed to sonar within the course of 1 day or a discreet continuous sonar event if less than 24 hours.

When modeling the effect of sound projectors in the water, the ideal task presents modelers with complete *a priori* knowledge of the location of the source(s) and transmission patterns during the times of interest. In these cases, calculation inputs include the details of source path, proximity of shoreline, high-resolution density estimates, and other details of the scenario. However, in the NWTRC, 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 CPA on Tuesday morning, how do we know it does not 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 D-11 lists unknowns created by uncertainty about the specifics of a future proposed action, the portion of the calculation to which they are relevant, and the assumption that allows the effect to be computed without the detailed information:

Table D-11. 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.

D.7.1 Multiple Exposures in General Modeling Scenario

Consider the following hypothetical scenario. A box is painted on the surface of a well-studied ocean environment with well-known propagation. A sonar-source and 100 whales are inserted into that box and a curtain is drawn. What will happen? The details of what will happen behind the curtain are unknown, but the existing knowledge, and general assumptions, can allow for a calculation of average 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 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 operating area (OPAREA) can be harassed. The intersection of this area with a given animal's habitat multiplied by the density of that animal in its habitat represents the maximum number of animals that can be harassed by activity in that OPAREA, which shall be defined as "the local population." Two details:

first, this maximum should be adjusted down if a risk function is being used, because not 100% of animals within X km of the OPAREA border will be harassed. Second, it should be adjusted up to account for animal motion in and out of the area.

The ambiguity of population freshness throughout the exercise means that multiple exposures cannot be calculated for any individual animal. It must be dealt with generally at the population level.

D.7.1.1 Solution to 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 km2 produces 100 expected harassments, then action A in an area with 1 animal per km2 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.

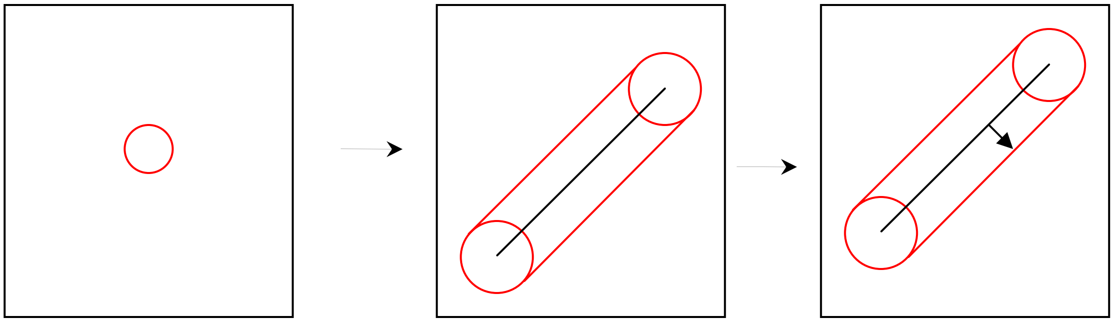
For example, consider the case where 1 animal is harassed per ping when the local population is 100, 100% of which are initially unharassed. After the first ping, 99 animals are unharassed, so the number of animals harassed during the second ping are

$$1\left(\frac{99}{100}\right) = 1(.99) = 0.99 \text{ animals}$$

and so on for the subsequent pings.

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 D-22).



$$H = \int\int\int \rho(z) D(L(x,y,z))dxdydz / N_{pings}$$

Figure D-22. Process of Calculating H

The total unharassed population is then calculated by iteration. Each ping affects the un-harassed population left after all previous pings:

Define P_n = unharassed population after ping *n*

$$P_0 = \text{local population}$$

$$P_1 = P_0 - H$$

$$P_2 = P_1 - H\left(\frac{P_1}{P_0}\right)$$

...

$$P_n = P_{n-1} - H\left(\frac{P_{n-1}}{P_0}\right)$$

Therefore,

$$P_n = P_{n-1}\left(1-\left(\frac{H}{P_0}\right)\right) = P_{n-2}\left(1-\left(\frac{H}{P_0}\right)\right)^2 = \ldots = P_0\left(1-\left(\frac{H}{P_0}\right)\right)^n$$

Thus, the total number of harassments depends on the per-ping harassment rate in an un-harassed population, the local population size, and the number of operation hours.

D.7.1.2 Local Population: Upper Bound on Harassments

As discussed above, Navy planners have confined periods of sonar use to training areas. The size of the harassed population of animals for an action depends on animal re-exposure, so uncertainty about the precise source path creates variability in the “harassable” population. Confinement of sonar use to a sonar training area allows modelers to compute an upper bound, or worst case, for the number of harassments with respect to location uncertainty. This is done by assuming that every animal which enters the training area at any time in the exercise (and also many outside) is “harassable” and creates an upper bound on the number of harassments for the exercise. Since this is equivalent to assuming that there are sonars transmitting simultaneously from each point in the confined area throughout the action length, this greatly overestimates the harassments from an exercise.

NMFS has defined a 24-hour “refresh rate,” or amount of time in which an individual can be harassed no more than once. The Navy has determined that, in a 24-hour period, all sonar activities in the NWTRC transmit for no longer than 2 hours.

The most conservative assumption for a single ping is that it harasses the entire population within the range (a gross over-estimate). However, the total harassable population for multiple pings will be even greater since animal motion over the period in the above table can bring animals into range that otherwise would be out of the harassable population.

D.7.1.3 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 NWTRC 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 NWTRC expansions use this estimate as an absolute upper bound on animal-motion expansion.

Figure D-23 illustrates an example of the overestimation, which occurs during the second arrow:

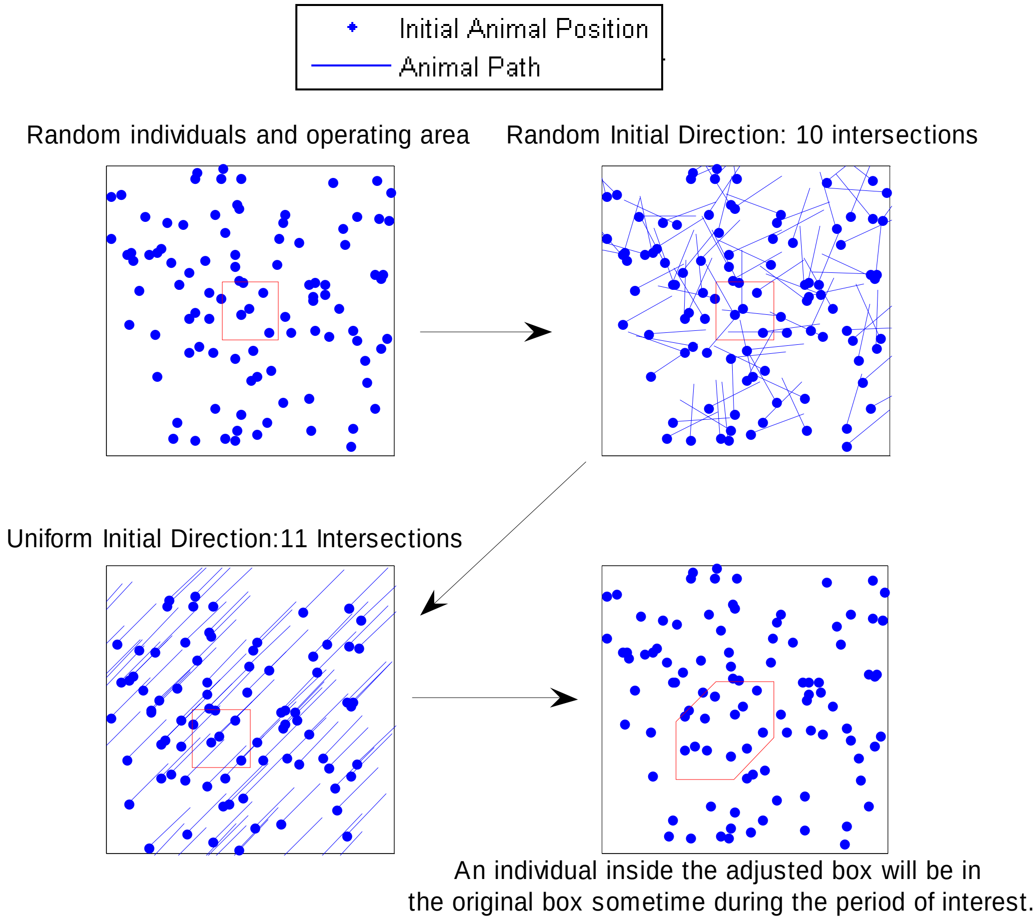


Figure D-23. Process of Setting an Upper Bound on Individuals Present in Area

It is important to recognize that the area used to calculate the harassable population, shown in Figure D-23 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 D-22. Using this smaller population would lead to a greater dilution of the unharassed population per ping and would greatly reduce the estimated harassments.

D.7.1.4 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 NWTRC, this would include all area within approximately 150 km from the edge of the adjusted box. This basic method would give a crude and exaggerated upper bound, since only a tiny fraction of this out-of-range area can be ensonified above threshold for a given ping. A more refined upper bound on harassments can be found by maintaining the assumption that a sonar is transmitting from each point in the adjusted box and calculating the expected ensonified area, which would give all animals inside the area a 100% 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 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 NWTRC, this method adds an area equivalent by expanding the boundaries of the adjusted box by 4 km. 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 D-24) 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.

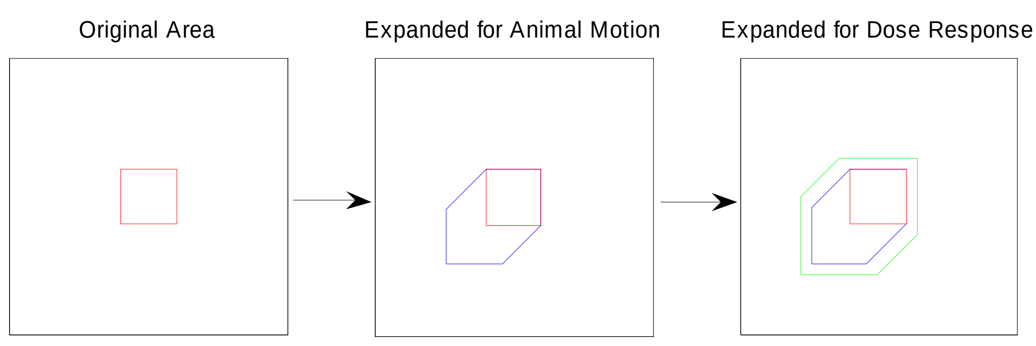


Figure D-24. Process of Expanding Area to Create Upper Bound of Harassments

D.7.1.5 Example Case

Consider a sample case from the NWTRC General Area. For the most powerful source, the 53C, the expected winter rate of harassment for short-finned pilot whales is approximately 0.00022128 harassments per ping. The exercise will transmit sonar pings for 2 hours in a 24-hour period as consistent with NWTRC planned use, with 120 pings per minute, a total of 120*2=240 pings in a 24-hour period.

The NWTRC General Area has an area of approximately 422,265 km^2 and a diagonal of 1,053 km. Adjusting this with straight-line (upper bound) animal motion of 5.5 km per hour for 2 hours, animal motion adds 1,053*5.5*2= 11,583 km^2 to the area. Using the risk function to calculate the expected range outside the SOA adds another 11,295 km^2, bringing the total upper-bound of the affected area to 445,143 km^2.

For this analysis, short-finned pilot whales have an average winter density of 0.00005 animals per km^2, so the upper bound number short-finned pilot whales that can be affected by 53C activity in the NWTRC during a 24-hour period is 445,143 *0.00005=22.3 whales.

In the first ping, 0.00022128 short-finned pilot whales will be harassed. With the second ping,

$0.00022128 \left(\frac{22.3 - 0.00022128}{22.3}\right) = 0.0002212778$ short-finned pilot whales will be harassed. Using the formula derived above, after 2 hours of continuous operation, the remaining **unharassed** population is $P_{240} = P_0\left(1-\left(\frac{h}{P_0}\right)\right)^{240} = 22.3\left(1-\left(\frac{.00022128}{22.3}\right)\right)^{240} \approx 22.25$

So the **harassed** population will be 22.3-22.25 = 0.05 animals.

Contrast this with linear accumulation of harassments without consideration of the local population and the dilution of the unharassed population:

Harassments = 0.00022128 * 240=0.053 animals

The difference in harassments is very small, as a percentage of total harassments, because the size of the NWTRC implies a large “harassable” population relative to the harassment per ping of the 53C. In cases where the harassable population is not as large, with respect to the per ping harassments, the difference in harassments between linear accumulation and density dilution is more pronounced.

D.7.2 Land Shadow

The risk function considers harassment possible if an animal receives 120 dB SPL, or above. In the open ocean of the NWTRC, this can occur as far away as 150 km, so over a large “effect” area, sonar sound could, but does not necessarily, harass an animal. The harassment calculations for a general modeling case must assume that this effect area covers only water fully populated with animals, but in some portions of the NWTRC, land partially encroaches on the area, obstructing sound propagation.

As discussed in the introduction of this section, 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 150 km of the grid, the azimuth and distance is computed. In the computation, only the minimum range at each azimuth is computed. The minimum range compared with azimuth for the sample point is shown in Figure D-25.

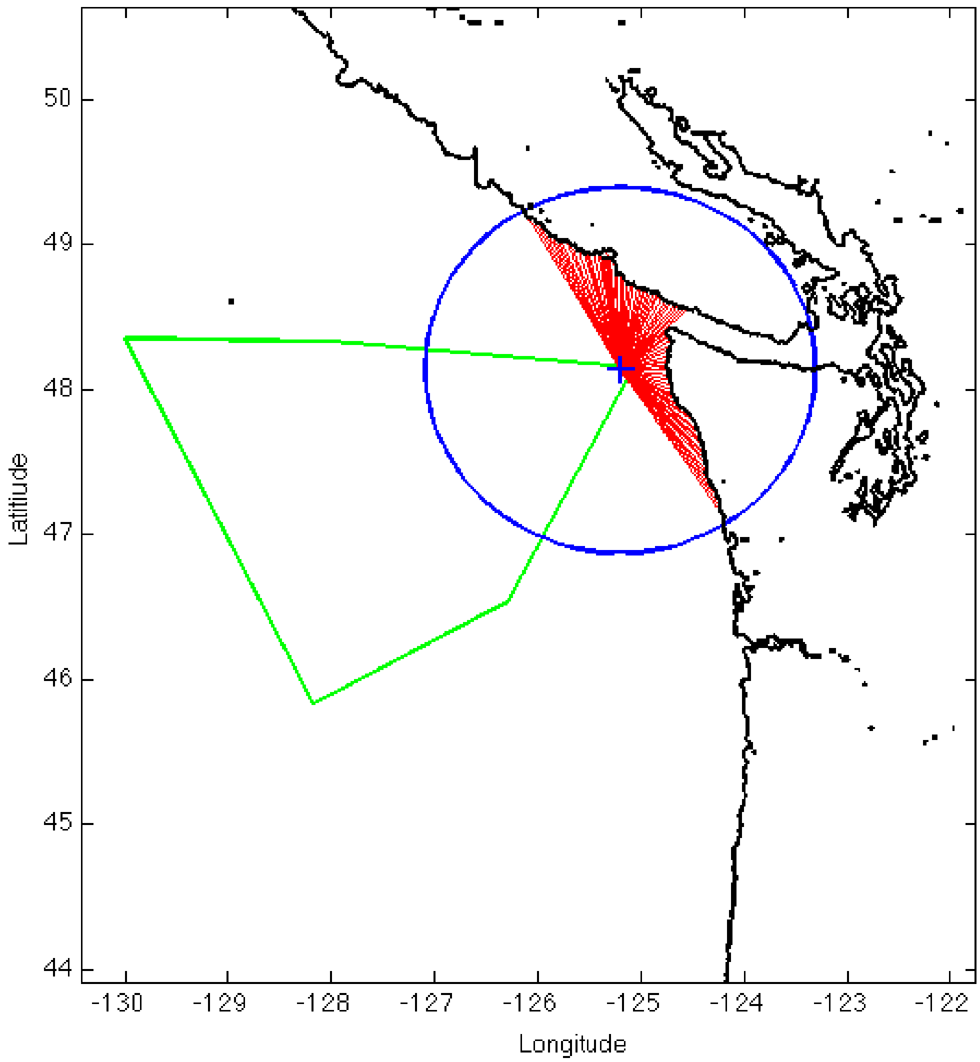


Figure D-25. The nearest point at each azimuth (with 1° spacing) to a sample grid point (red circle) is shown by the green lines.

Now, the average of the distances to shore, along with the angular profile of land is computed (by summing the unique azimuths that intersect the coast) for each grid point. The values are then used to compute the land shadow for the grid points.

D.7.2.1 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. Table D-12 and Figure D-26 give a mathematical extrapolation of the distances and levels at which harassments occur, with average propagation in the NWTRC.

Table D-12. Behavioral Harassments at each Received Level Band from 53C

Received Level (dB SPL)	Distance at which Levels Occur in NWTRC	Percent of Behavioral Harassments Occurring at Given Levels
Below 140	51 km - 130 km	< 1%
140<Level<150	25 km – 51 km	2%
150<Level<160	10 km – 25 km	18%
160<Level<170	3 km – 10 km	43%
170<Level<180	560 m – 3 km	28%
Above 180 dB	0 m – 560 m	< 9%

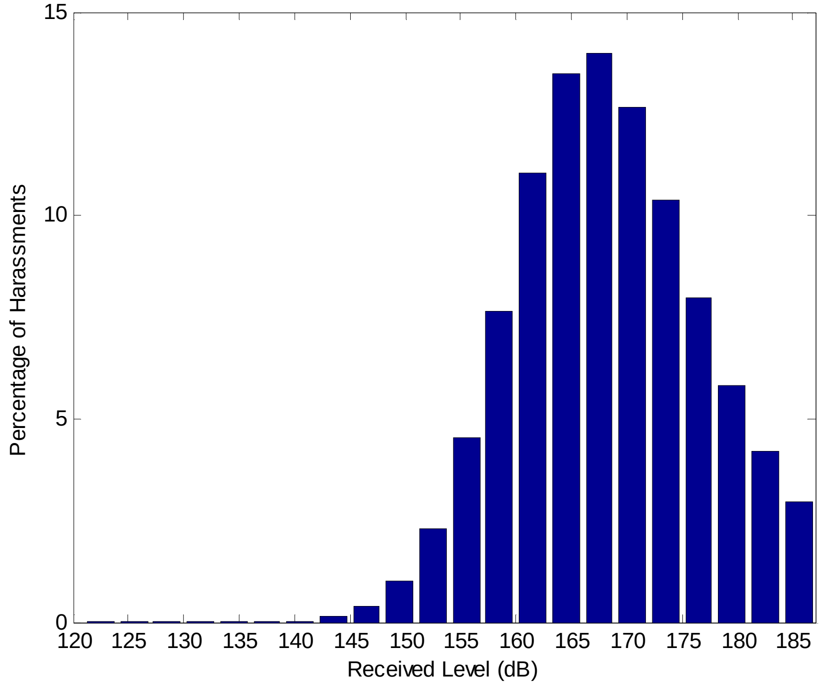


Figure D-26. Approximate Percentage of Behavioral Harassments for Every 5 Degree Band of Received Level from the 53C

With the data used to produce the previous figure, the average effect reduction across season for a sound path blocked by land can be calculated. For the 53C, since approximately 81% of harassments occur within 10 km of the source (Figure D-27), a sound path blocked by land at 10 km will, on average, cause approximately 81% of the effect of an unblocked path.

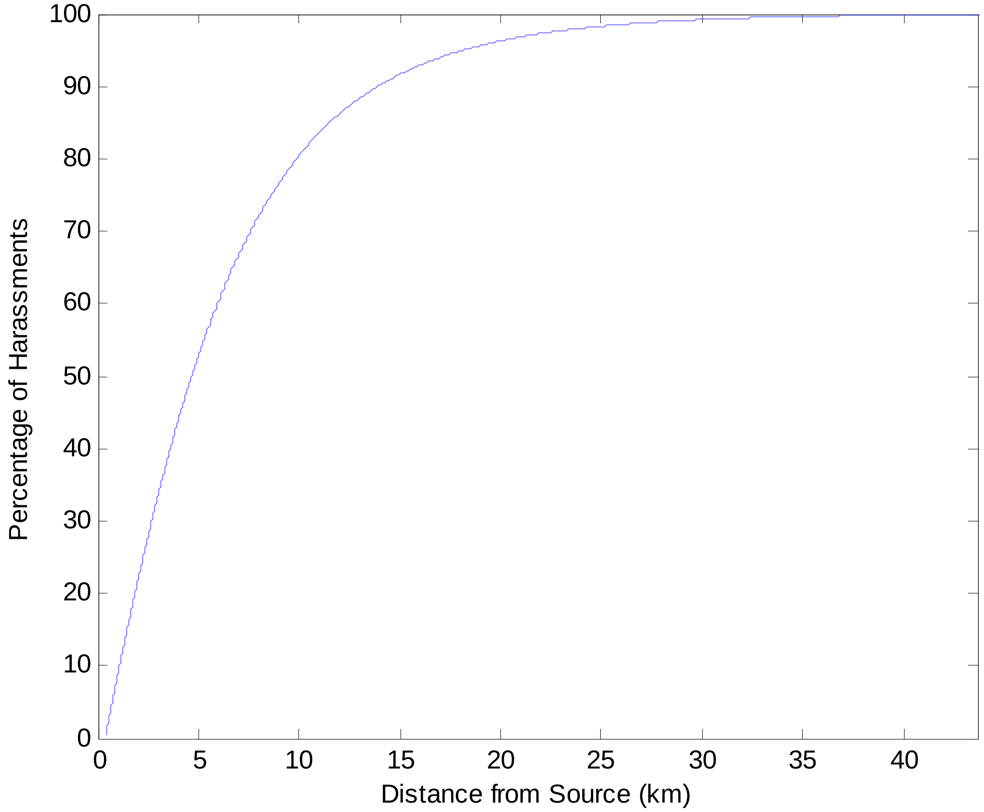


Figure D-27. Average Percentage of Harassments Occurring Within a Given Distance

As described above, the mapping process determines the angular profile of and distance to the coastline(s) from each grid point. The distance, then, determines the reduction due to land shadow when the sonar is pointed in that direction. The angular profile, then, determines the probability that the sonar is pointed at the coast.

Define θn = angular profile of coastline at point n in radians

Define rn = 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, Figures D-28 and D-29 give the land shadow reduction factor at each point in each range area for the 53C. The white portions of these figures 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 from the 53C for the NWTRC is 0.9992 and for the special case of harbor porpoises is 0.9116; the reduction in effect is 0.0008% for the former and 8.84% for the latter. For the other, lower-power sources, this reduction is negligible.

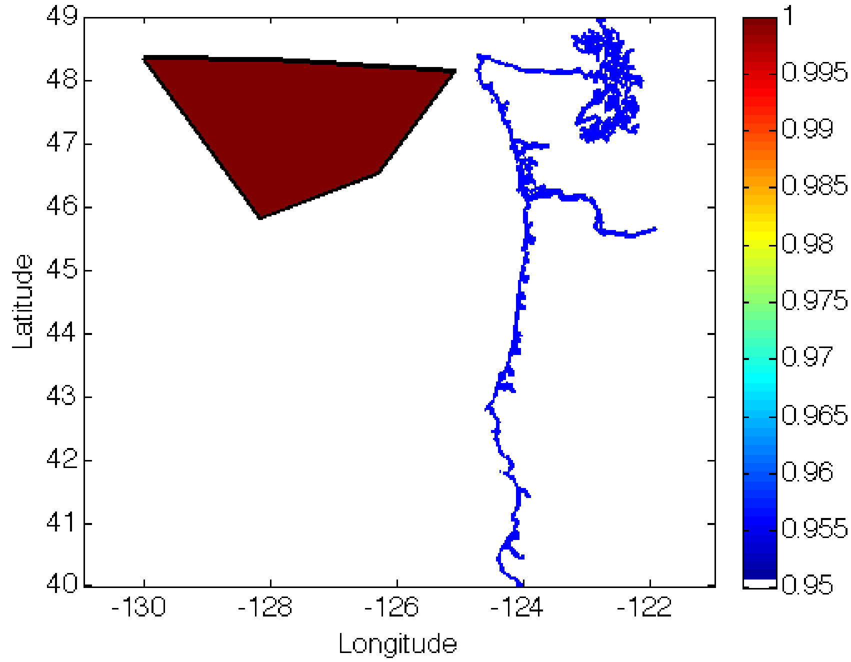


Figure D-28. Depiction of Land Shadow over Warning Area 237

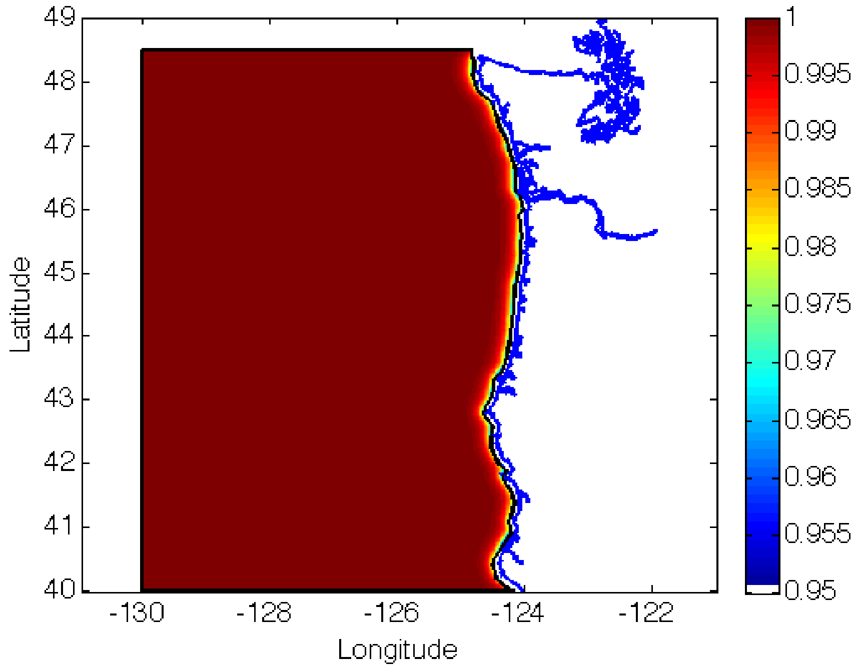


Figure D-29. Depiction of Land Shadow over NWTRC

D.8 REFERENCES

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Appendix E

Cetacean Stranding Report

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E CETACEAN STRANDING REPORT

E.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 familiarity 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.

E.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 (Southhall, 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 whales and humpback whales (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).

E.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). Detailed regional stranding information including most commonly stranded species can be found in Zimmerman (1991), Geraci and Lounsbury (2005), and NMFS (2007).

Stranding data is presented in Table E-1 and Figure E-1 below.

Table E-1. Cetacean And Pinniped Stranding Count By NMFS Region 2001-2004.

NMFS Region	# of Cetaceans	# of Pinnipeds
Northeast	1,620	4,050
Southeast	2,830	45
Southwest	12,900	45
Northwest	188	1,430
Alaska	269	348
Pacific Islands	59	10
Four Year Total	17,866	5,928

Source: NMFS 2007

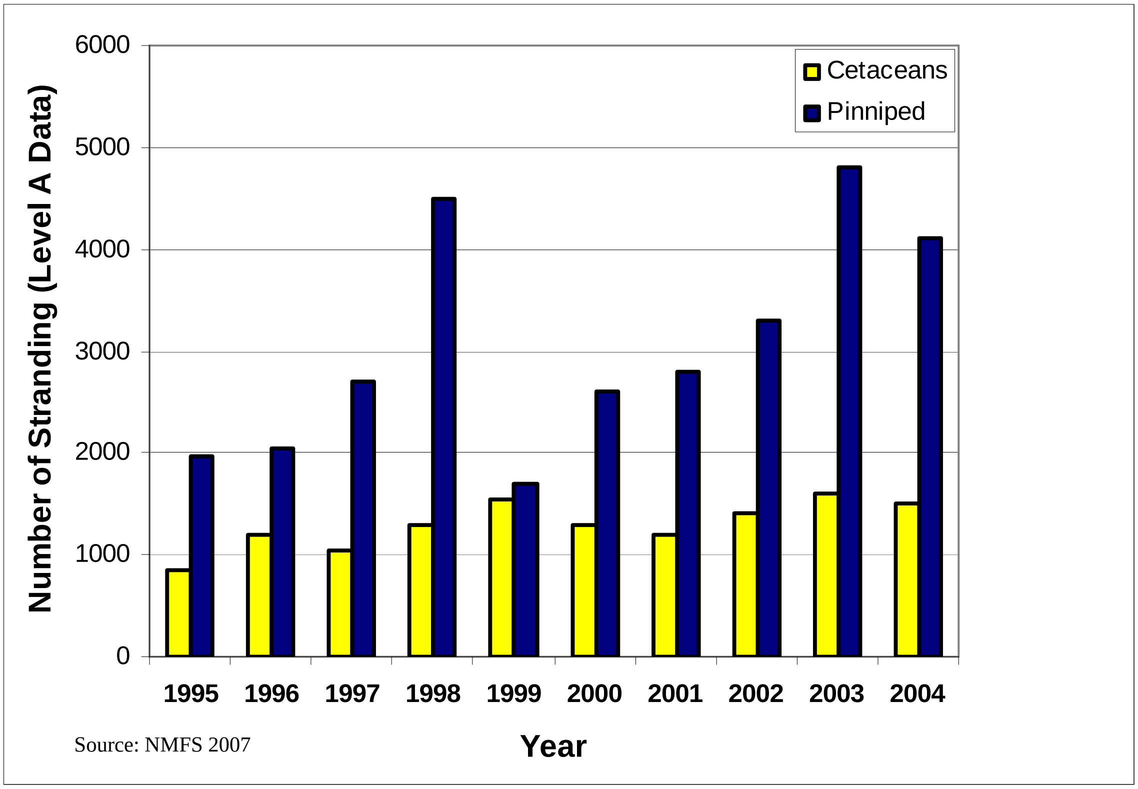


Figure E-1. United States Annual Cetacean And Pinniped Stranding From 1995-2004.

E.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 E-2 contains a list of documented UMEs in and along the Pacific coast of the U.S.

E.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.

Table E-2. Documented UMEs within the United States.

Year	Composition	Determination
1993	Harbor seals, Steller sea lions, and California sea lions on the central Washington coast	Human Interaction
1993/1994	Bottlenose dolphins in the Gulf of Mexico	Morbillivirus
1994	Common dolphins in California	Cause not determined
1996	Right whales off Florida/Georgia coast	Evidence of human interactions
1996	Manatees on the west coast of Florida	Brevetoxin
1996	Bottlenose dolphins in Mississippi	Cause not determined
1997	Harbor seals in California	Unknown infectious respiratory disease
1997	Pinnipeds on the Pacific coast	El Niño
1998	California sea lions in central California	Harmful algal bloom; Domoic acid
1999	Harbor porpoises on the East Coast	Determined not to meet criteria for UME because of multiplicity of causes
1999/2000	Bottlenose dolphins in the Panhandle of Florida	Harmful algal bloom is suspected; still under investigation
1999/2000	Gray whales from Alaska to Mexico	Still under investigation
2004	Bottlenose dolphins along the Florida Panhandle	Uncertain, red tide is suspected
2005	Bottlenose dolphins, manatees, sea turtles, and seabirds in west central Florida	Unknown

Source: NMFS 2007

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

E.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 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 E-2 shows U.S. animal mortalities from 1997-2006 resulting from toxins produced during harmful algal blooms.

In the Gulf of Mexico and mid- to southern Atlantic states, "red tides," a form of harmful algal bloom, are created by a dinoflagellate (*Karenia brevis*). *K. brevis* is found throughout the Gulf of Mexico and sometimes along the Atlantic coast (Van Dolah 2005; NMFS 2007). It produces a neurotoxin known as brevetoxin. Brevetoxin has been associated with several marine mammal UMEs within this area (Geraci, 1989; Van Dolah et al., 2003; NMFS, 2004; Flewelling et al., 2005; Van Dolah, 2005; NMFS, 2007). On the U.S. West Coast and in the northeast Atlantic, several species of diatoms produce a toxin called domoic acid which has also been linked to marine mammal strandings (Geraci et al., 1999; Van Dolah et al., 2003; Greig et al., 2005; Van Dolah, 2005; Brodie et al., 2006; NMFS, 2007; 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).

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.

Source: Woods Hole Oceanographic Institute (WHO) http://www.whoi.edu/redtide/HABdistribution/HABmap.html

Figure E-2. Animal Mortalities from Harmful Algal Blooms within the U.S., 1997-2006.

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).

E.1.4.2 Anthropogenic Stranding Causes and Potential Risks

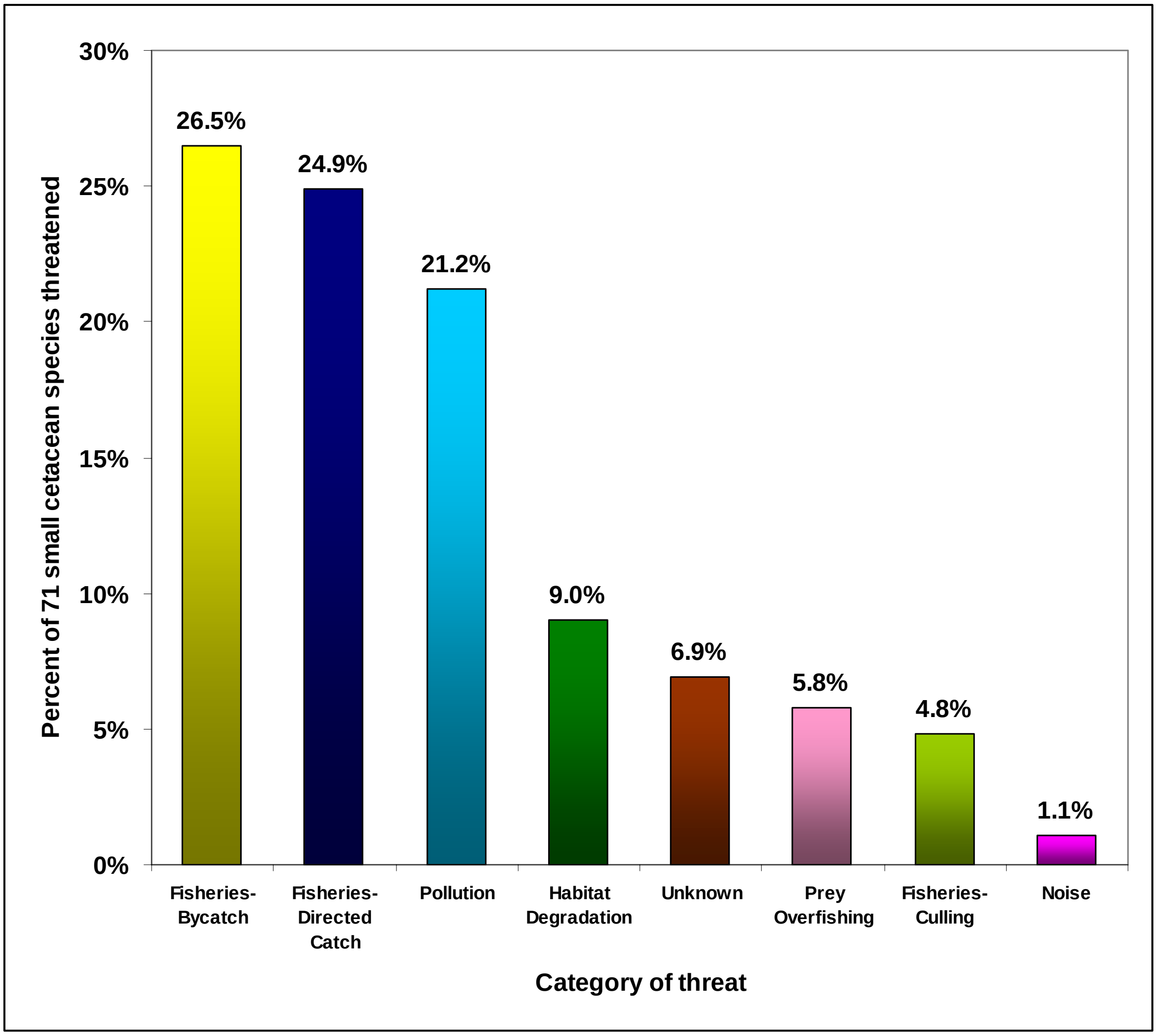
With the exception of historic whaling in the 19th and early part of the 20th century, over the past few decades there has been an increase in marine mammal mortalities associated with a variety of human activities (Geraci et al., 1999; NMFS, 2007). These include fisheries interactions (bycatch and directed catch), pollution (marine debris, toxic compounds), habitat modification (degradation, prey reduction), direct trauma (vessel strikes, gunshots) and noise. Figure E-3 show potential worldwide risk to small toothed cetaceans by source.

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 had 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). Eighty-four percent of cetacean bycatch occurred in gill-net fisheries, with dolphins and porpoises constituting most of the cetacean bycatch (Read et al., 2006). Over the decade there was a 40 percent decline in marine mammal bycatch, 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).



(Source: Culik 2002)

Figure E-3. Human Threats to World Wide Small Cetacean Populations

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 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 percent 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 percent as vessel speed increased from 10 to 14 knots, and exceeded 90 percent 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 sound 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 vessel's noise emission into the marine environment. Propellor-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 signatures (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 areas 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.

E.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 cannot be attributed to any one component, since the source was such a mix of signal types.

The effects of naval sonar 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 exposure 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 airgun 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 1,000 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, temporary in nature, and therefore effects are likely indirect and to be short lived. 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 thoroughly investigates 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 (Table 2-5). 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 1970s (Jane’s 2005).

E.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 cannot 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 cannot be associated with naval operations.

E.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)

<u>Case Studies of Stranding Events (coincidental with or implicated with naval sonar)</u>

1996 Greece Beaked Whale Mass Stranding (May 12–13, 1996)

<u>Description</u>: 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).

<u>Findings</u>: 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 other seven 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 one Gervais' beaked whale were necropsied; six of them within 12 hours of stranding (Fernández et al., 2005). The stomachs of the whales contained fresh and undigested prey contents. No pathogenic bacteria were isolated from the whales, although parasites were found in the kidneys of all of the animals. The head and neck lymph nodes were congested and hemorrhages were noted in multiple tissues and organs, including the kidney, brain, ears and jaws. Widespread fat emboli were found throughout the carcasses, but no evidence of blunt trauma was observed in the whales. In addition, the parenchyma of several organs contained macroscopic intravascular bubbles and lesions, putatively associated with nitrogen off-gassing.

Conclusions: The association of NATO mid-frequency sonar use close in space and time to the beaked whale strandings and the similarity between this stranding event and previous beaked whale mass strandings coincident with sonar use suggest 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 26-28, 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 1,000 meters in depth near a shoreline where there is a rapid change in bathymetry on the order of 1,000 to 6,000 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)

E.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).

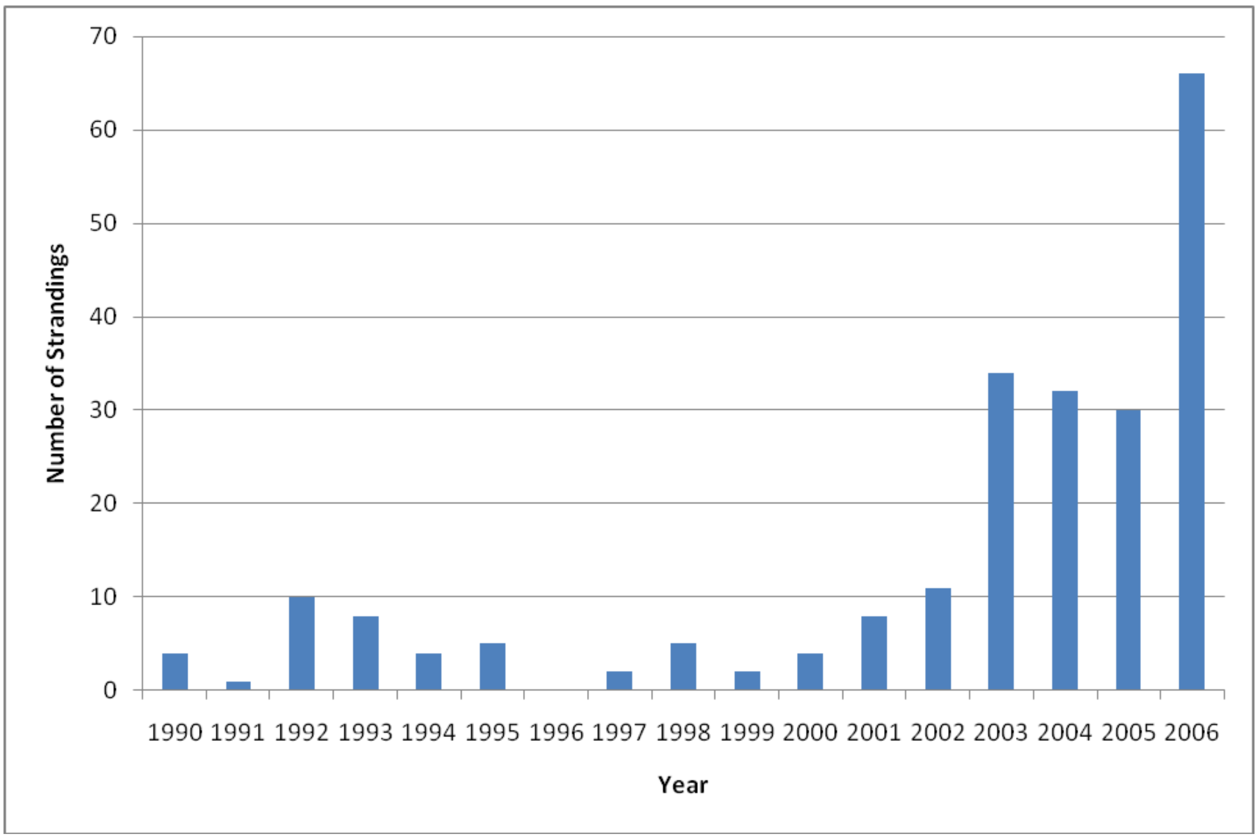
<u>Findings</u>: Post-mortem findings and analysis details are found in Norman et al. (2004). All of the carcasses suffered from some degree of freeze-thaw artifact that hampered gross and histological evaluations. At the time of necropsy, three of the porpoises were moderately fresh; the remainder of the carcasses were 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 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.

<u>Conclusions</u>: 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).

Figure E-4. Northwest Region Harbor Porpoise Strandings 1990 - 2006



Source: NOAA Fishereis, Northwest Region, 2006b

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 support 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 SHOUP, any other potential causal factor or a combination of factors.

Orca: Observer opinions regarding orca J-Pod behaviors on May 5, 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 May 5, 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 vessel 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 spyhopping. No predators were observed in the bay and no animals were reported 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 to 4.0 m/s for 6.5 to 17.5 hours after sonar transmissions ceased to reach Hanalei Bay by 7 a.m. on July 3. Sound transmissions by ships to the north of Hanalei Bay on July 3 were produced as part of exercises between 6:45 a.m. and 4:47 p.m. Propagation analysis conducted by the 3rd Fleet estimated that the level of sound from these transmissions at the mouth of Hanalei Bay could have ranged from 138-149 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 to 700 melon-headed whales were observed to come close to shore and interact with humans in Sasanhaya Bay, Rota, on the same morning as the whales entered Hanalei Bay (Jefferson et al., 2006). Previous records further indicated that, though the entrance of melon-headed whales into the shallows is rare, it is not unprecedented. A pod of melon-headed whales entered Hilo Bay in the 1870s in a manner similar to that which occurred at Hanalei Bay in 2004.

The necropsy of the melon-headed whale calf suggested that the animal died from a lack of nutrition, 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)

Description: Brownell et al. (2004) compared the historical occurrence of beaked whale strandings in Japan (where there are U.S. Navy 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 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).

E.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 suggests 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 SOCAL Range Complex 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.

E.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 have 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).

Appendix F

Public Scoping Summary

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F PUBLIC SCOPING SUMMARY

F.1 GENERAL SUMMARY OF THE SCOPING PERIOD

The scoping period for the Northwest Training Range Complex (NWTRC) Environmental Impact Statement (EIS)/Overseas EIS (OEIS) began with publication of a Notice of Intent on July 31, 2007. The scoping period lasted 60 days, concluding on September 29, 2007. Five scoping meetings were held on September 10, 11, 12, 13, and 15 in the cities of: Oak Harbor, WA; Pacific Beach, WA; Grays Harbor, WA; Depoe Bay, OR; and Eureka, CA respectively. The scoping meetings were held in an open house format, presenting informational posters and written information and making Navy staff and project experts available to answer participants' questions. Additionally, a tape recorder was available to record participants' oral comments. The interaction during the information sessions was productive and helpful to the Navy.

Scoping participants could submit comments in five ways:

- Oral statements at the public meetings (as recorded by the tape recorder);
- Written comments at the public meetings;
- Written letters (received any time during the public comment period);
- Electronic mail (received any time during the public comment period); and
- Comments submitted directly on the project website (received any time during the public comment period).

In total, the Navy received comments from 50 individuals and groups. Because many of the comments addressed more than one issue, 191 total comments resulted. This summary provides an overview of comments received through these means during the scoping period. Comments are organized by issue area.

F.2 AIR QUALITY

Comments in this category expressed concern about the effects of military activities on air quality, including off-shore emissions that may be transmitted ashore by onshore winds. The EIS/OEIS should discuss which areas are in nonattainment of National Ambient Air Quality Standards.

F.3 ALTERNATIVES

Most comments regarding alternatives suggested that the Navy consider other sites to conduct its activities. Several comments expressed concern over potential impacts to the Olympic Coast National Marine Sanctuary (OCNMS).

F.4 BIOLOGICAL RESOURCES – MARINE MAMMALS, FISH AND MARINE HABITAT

A significant number of comments received expressed concerns about impacts to marine life. Many of these comments specifically related to concerns about the effect of Navy sonar on marine life, such as marine mammals, fish, sea turtles, and sea invertebrates. Participants frequently requested that the EIS/OEIS consider alternative technologies to mid-frequency active (MFA) sonar. Several comments addressed protective and mitigation measures for marine mammals when sonar is used. Other comments identified specific policies that must be considered in the Navy's analysis, such as the Marine Mammal Protection Act.

F.5 BIOLOGICAL RESOURCES—ONSHORE

Several comments addressed the protection of birds, including shorebirds, seabirds, and migratory birds. Potential stressors to birds mentioned in the comments included bird strikes and noise disturbance. Among other terrestrial issues mentioned were concerns about habitat fragmentation and potential damage to intertidal, inland, or upland resources.

F.6 CULTURAL RESOURCES

Participants commenting on cultural resources were primarily concerned with impacts to tribal access, and recreational and subsistence fishing. A few comments also addressed the issue of potential damage to historically or culturally significant sites.

F.7 CUMULATIVE IMPACTS

Comments in this category expressed concern about the overall impact of past and present military activity in the Pacific Northwest and requested that the Navy initiate cleanup activities. Specific mention was made of the cumulative nature of activities at Naval Magazine Indian Island and the Naval Undersea Warfare Center Keyport Range. Additional comments requested that the Navy study the impacts of other actions, such as placement of wave electrical generation equipment, wind generators on Bear Ridge, and activities at Coast Guard Station Humboldt Bay and Eureka/Arcata airport.

F.8 ENVIRONMENTAL JUSTICE

Commenters requested that the EIS/OEIS identify any disproportionate impacts to disempowered groups of people.

F.9 HAZARDOUS MATERIALS

Of the comments regarding hazardous materials, the primary concern was the effects of depleted uranium use on the environment in general.

F.10 HEALTH AND SAFETY

One comment expressed concern about safety implications to commercial and recreational divers from MFA sonar. Another commenter was concerned about potential increases in aviation mishaps with increased unmanned aerial system use.

F.11 NOISE

Several commenters expressed concern about any increase in airborne noise that could result from increased aircraft activity or offshore gun or bomb training.

F.12 MISCELLANEOUS

Comments were received that requested that the EIS/OEIS consider the protection of surfing waves and for analysis of impact to research activities.

F.13 MITIGATION MEASURES

Most comments regarding mitigation measures focused on marine mammals. For example, it was requested that the Navy employ better protective measures in future sonar exercises, such as conducting more monitoring and enforcing larger safety zones around ships. Several comments mentioned special mitigation measures in and around the OCNMS.

F.14 POLICY/NATIONAL ENVIRONMENTAL POLICY ACT PROCESS

Comments on the National Environmental Policy Act (NEPA) process included several that felt the information available during scoping was not adequate enough to generate comments. One commenter requested that the scoping period be extended beyond 60 days and that another scoping meeting be held in Seattle.

F.15 RECREATION

One comment expressed concern about closing navigable waters for military activities. Such closures would negatively impact recreational fishing, boating and diving.

F.16 SOCIOECONOMICS

Several comments regarding socioeconomic concerns included questions about the effects on commercial shipping, commercial diving and commercial fishing.

F.17 SONAR AND UNDERWATER DETONATIONS

Many comments mentioned concerns about the effect of Navy sonar on marine life, such as marine mammals, fish, sea turtles, and sea invertebrates. Participants frequently requested that the EIS/OEIS consider alternative technologies to MFA sonar. Several comments addressed protective and mitigation measures for marine mammals when sonar is used. Three comments specifically mentioned concerns about underwater detonations and their potential impact to the marine environment.

F.18 WATER RESOURCES

Comments regarding water resources included general concerns about the potential for water quality to be affected by military activities.

F.19 SUMMARY OF COMMENTS

Table F-1 provides a breakdown of areas of concern based on comments received during scoping.

Table F-1: Breakdown of Scoping Comments by Resource Area

Resource Area	Count	Percent of Total
Biological Resources - Marine Mammals	23	12.04%
Biological Resources - Fish & Marine Habitat	17	8.90%
Sonar Underwater Detonations	16	8.38%
Policy/NEPA	14	7.33%
Olympic Coast National Marine Sanctuary	12	6.28%
Other Navy EIS Studies and Unrelated Activities	12	6.28%
Water Resources	11	5.76%
Recreation	9	4.71%
Socioeconomics	9	4.71%
Cultural Resources	8	4.19%
Cumulative Impacts	7	3.66%
Health and Safety	7	3.66%
Threatened and Endangered Species	7	3.66%
Biological Resources - Onshore	6	3.14%
Mitigation	6	3.14%
Proposed Action	6	3.14%
Alternatives	5	2.62%
Noise	5	2.62%
Hazardous Materials / Hazardous Waste	4	2.09%
Miscellaneous	4	2.09%
Air Quality	2	1.05%
Environmental Justice	1	0.52%
TOTAL	191	