Environmental Impact Statement/

Overseas Environmental Impact Statement

Point Mugu Sea Range

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3 Affected Environment and Environmental Consequences

3.0 Introduction

This chapter provides information on Navy compiled and generated data, the Navy's Acoustic Effects Model, and Overall Approach to Analysis. Sections 3.1 through 3.14 describe the affected environment and environmental consequences for 14 resource areas: air quality, sediments and water quality, marine habitats, marine vegetation, marine invertebrates, marine fishes, marine mammals, sea turtles, marine birds, cultural resources, socioeconomics, recreation, sea and airspace, and public health and safety. Information on these resource areas provides baseline conditions from which to identify and evaluate potential impacts that could result from implementation of the Proposed Action. The information presented is commensurate with the level of potential impacts in order to provide the proper context for the analysis.

Resources considered but not carried forward for full analysis include terrestrial species (plants and animals) within the project area. As discussed in Section 1.7.4 (Related Environmental Documents) and elsewhere in this Environmental Impact Statement (EIS)/Overseas Environmental Impact Statement (OEIS), the Navy has developed environmental assessments for activities conducted on the Point Mugu Sea Range (PMSR) since the 2002 EIS/OEIS. There are no proposed changes in tempo or locations proposed for land-based activities on Naval Base Ventura County (NBVC) Point Mugu and San Nicolas Island (SNI) from previous analyses in the 2002 EIS/OEIS and subsequent environmental assessments; therefore, in consultation with the United States (U.S.) Fish and Wildlife Service, it was determined that the existing biological opinions are still valid to support the Proposed Action, and no additional analysis was needed. The Navy proposes to continue to implement the protective measures contained within the Biological Opinions relative to the Proposed Action of this EIS/OEIS, which are discussed in detail in Chapter 5 (Standard Operating Procedures and Mitigation).

3.0.1 Navy Compiled and Generated Data

While preparing this document, the U.S. Department of the Navy (Navy) used the best available data, science, and information accepted by the relevant and appropriate regulatory and scientific communities to establish a baseline in the environmental analyses for all resources in accordance with the National Environmental Policy Act, the Administrative Procedure Act (5 United States Code sections 551–596), and Executive Order 12114.

The Navy sponsors and supports both internal and independent research and monitoring efforts in support of the environmental baseline and environmental consequences sections for this and other environmental documents. The Navy's applicable research and monitoring programs, as described below, are largely focused on filling data gaps and obtaining the most up-to-date science.

3.0.2 Marine Species Monitoring and Research Programs

The Navy has been conducting marine species monitoring for compliance with the Marine Mammal Protection Act (MMPA) and Endangered Species Act (ESA) since 2006, both in association with testing and training events and independently. In addition to monitoring activities associated with regulatory compliance, two other Navy research programs provide extensive investments in basic and applied research: the Office of Naval Research Marine Mammals & Biology program, and the Living Marine Resources program. In fact, the U.S. Navy is one of the largest sources of funding for marine mammal research in the world. A survey of federally funded marine mammal research and conservation conducted by the Marine Mammal Commission found that the Navy was the second-largest source of funding for marine mammal activities (direct project expenditures, as well as associated indirect or support costs) in the United States in 2020, second only to National Oceanic and Atmospheric Administration Fisheries.

The monitoring program has historically focused on collecting baseline data that supports analysis of marine mammal occurrence, distribution, abundance, and habitat use preferences in and around ocean areas in the Atlantic and Pacific where the Navy conducts activities. More recently, the priority has begun to shift towards assessing the potential response of individual species to Navy activities. Data collected through the monitoring program serves to inform the analysis of impacts on marine mammals with respect to species distribution, habitat use, and potential responses to testing and training activities. Monitoring is performed using various methods, including visual surveys from surface vessels and aircraft, passive acoustics, and tagging. Additional information on the program is available on the U.S. Navy Marine Species Monitoring Program website (https://www.navymarinespeciesmonitoring.us/), which serves as a public online portal for information on the background, history, and progress of the program and provides access to reports, documentation, data, and updates on current monitoring projects and initiatives.

The two other Navy programs previously mentioned invest in research on the potential effects of sound on marine species and develop scientific information and analytic tools that support preparation of environmental impact statements and associated regulatory processes under the MMPA and ESA, as well as support development of improved monitoring and detection technology and advance overall knowledge about marine species. These programs support coordinated science, technology, research, and development focused on understanding the effects of sound on marine mammals and other marine species, including physiological, behavioral, ecological, and population-level effects.

3.0.3 Developing Acoustic and Explosive Criteria and Thresholds

Information about the numerical sound and energy levels that are likely to elicit certain types of physiological and behavioral reactions is needed to analyze potential impacts on marine species. Navy criteria and thresholds for quantitative modeling of impacts use the best available existing data from scientific journals, technical reports, and monitoring reports to develop thresholds and functions for estimating impacts on marine species. Working with the National Marine Fisheries Service, the Navy has developed updated criteria for marine mammals and sea turtles. A detailed description of the acoustic and explosive criteria and threshold development is included in the supporting technical report *Criteria and Thresholds for U.S. Navy Acoustic and Explosive Impact to Marine Mammals and Sea Turtles* (U.S. Department of the Navy, 2017).

A series of behavioral studies, largely funded by the U.S. Navy, has led to a new understanding of how some species of marine mammals react to sound produced from military sonar and explosives. This resulted in developing new behavioral response functions for estimating alterations in behavior. Additional information on auditory weighting functions has also emerged [e.g., (Mulsow et al., 2015)], leading to developing a new methodology to predict auditory weighting functions for each hearing group along with the accompanying hearing loss thresholds. These criteria for predicting hearing loss in marine mammals were largely adopted by the National Marine Fisheries Service for species within their purview (National Marine Fisheries Service, 2018).

The Navy also uses criteria for estimating effects to fishes and the ranges to which those effects are likely to occur. Criteria for estimating impacts on marine fishes used in this analysis largely follows the

Sound Exposure Guidelines for Fishes and Sea Turtles (Popper et al., 2014). A working group of experts generated a technical report that provides numerical criteria and the relative likelihood of effects to fish within different hearing groups (i.e., fishes with no swim bladder versus fishes with a swim bladder involved in hearing) (Popper et al., 2014).

3.0.4 The Navy's Acoustic Effects Model

The Navy's Acoustic Effects Model calculates sound energy propagation from explosives during at-sea naval activities and the energy or sound received by animat dosimeters. Animat dosimeters are virtual representations of marine mammals or sea turtles distributed in the area around the modeled naval activity; each animat records its individual sound "dose." The model bases the distribution of animats over the Study Area on the density values in the Navy Marine Species Density Database and distributes animats in the water column proportional to the known time that species spend at varying depths.

The model accounts for environmental variability of sound propagation in both distance and depth when computing the received sound level on the animats. The model conducts a statistical analysis based on multiple model runs to compute the estimated effects on animals. The number of animats that exceed the received threshold for an effect is tallied to provide an estimate of the number of marine mammals or sea turtles that could be affected.

Assumptions in the Navy model intentionally err on the side of overestimation when there are unknowns:

- Naval activities are modeled as though they would occur regardless of absence or presence and proximity to marine mammals or sea turtles (i.e., mitigation is not modeled) and without any avoidance of the activity by the animal. The final step of the quantitative analysis of acoustic effects is to consider the implementation of mitigation, if practical.
- Many explosions from munitions such as bombs and missiles occur upon impact with above-water targets and at the water's surface. However, for this analysis, sources such as these were modeled as exploding under the water surface. This overestimates the amount of explosive and acoustic energy entering the water.

The model estimates the impacts caused by individual testing and training activities. During any individual modeled event, impacts on individual animats are considered over 24-hour periods. The animats do not represent actual animals, but rather allow for a statistical analysis of the number of instances that marine mammals or sea turtles may be exposed to sound levels resulting in an effect. Therefore, the model estimates the number of instances in which an effect threshold was exceeded over the course of a year, but does not estimate the number of individual marine mammals or sea turtles that may be impacted over a year (i.e., some marine mammals or sea turtles could be impacted several times, while others would not experience any impact). A detailed explanation of the Navy's Acoustic Effects Model is provided in the draft technical report *Quantifying Acoustic Impacts on Marine Species: Methods and Analytical Approach for Activities at the Point Mugu Sea Range* (U.S. Department of the Navy, 2019).

3.0.5 Overall Approach to Analysis

For purposes of this EIS/OEIS, both an activity-based and stressor-based approach to analysis were applied.

3.0.5.1 Activity-Based Analysis

For physical resources (air quality, sediments and water quality) and human resources (socioeconomic resources, and public health and safety) an activity-based approach is conducted and described in their respective sections of this chapter.

3.0.5.2 Stressor-Based Analysis

A stressor-based analysis is conducted for biological and cultural resources. Stressors for biological resource sections are applicable to marine habitats, marine vegetation, marine invertebrates, marine fishes, marine mammals, sea turtles, and marine birds and are discussed in detail below. For cultural resources, the methodology and stressors are unique for that resource; therefore, details are described in Section 3.10 (Cultural Resources).

For biological resources, proposed Navy activities under each alternative were evaluated to identify specific components that could act as stressors (stimuli that cause a response in an organism) by having direct or indirect impacts on biological resources (e.g., marine habitats, marine birds, marine mammals). The Navy's overall approach to analysis for biological resources in this EIS/OEIS included the following general steps:

- identifying resources and stressors for analysis,
- analyzing resource-specific impacts for individual stressors,
- examining potential marine species population-level impacts,
- analyzing cumulative effects, and
- analyzing mitigations to reduce identified potential impacts.

Under the Proposed Action, Navy testing activities may produce one or more stimuli that cause stress on a resource. Each proposed Navy activity was examined to determine its potential stressors. The term stressor is broadly used in this document to refer to an agent, condition, or other stimulus that causes stress to an organism. Not all stressors affect every resource, nor do all proposed Navy activities produce all stressors. Since the activities proposed in this EIS/OEIS are similar to current activities analyzed previously, the stressors considered are also similar.

The potential direct, indirect, and cumulative impacts of the Proposed Action were analyzed based on these potential stressors being present with the resource. Data sets used for analysis were considered across the full spectrum of Navy training and testing for the foreseeable future. Direct impacts are caused by the action and occur at the same time and place. Indirect impacts result when a direct impact on one resource induces an impact on another resource (referred to as a secondary stressor). Indirect impacts would be reasonably foreseeable because of a functional relationship between the directly impacted resource and the secondarily impacted resource. For example, a significant change in water quality could secondarily impact those resources that rely on water quality, such as marine animals. Cumulative effects or impacts are the incremental impacts of the action added to other past, present, and reasonably foreseeable future actions.

First, a preliminary analysis was conducted to determine the environmental resources potentially impacted and associated stressors. Secondly, each resource was analyzed for potential impacts of individual stressors, followed by an analysis of the combined impacts of all stressors related to the Proposed Action. A cumulative impact analysis was conducted to evaluate the incremental impact of the Proposed Action when added to other past, present, and reasonably foreseeable future actions (Chapter 4, Cumulative Impacts). Mitigation measures are discussed in detail in Chapter 5 (Standard

Operating Procedures and Mitigation), and regulatory considerations are discussed in Chapter 6 (Other Regulatory Considerations).

In this sequential approach, the initial analyses were used to develop each subsequent step so that the analysis focused on relevant issues (defined during scoping) that warranted the most attention. The systematic nature of this approach ensured that associated stressors and potential impacts associated with the Proposed Action were effectively tracked throughout the process. This approach provides a comprehensive analysis of applicable stressors and potential impacts.

3.0.5.3 Resource-Specific Impacts Analysis for Individual Stressors

The direct and indirect impacts of each stressor are analyzed in each biological resource section for which there may be an impact. Quantitative methods were used to the extent possible, but data limitations required the use of qualitative methods for most stressor/resource interactions. Resource-specific methods are described in sections of this chapter, where applicable. While specific methods used to analyze the impacts of individual stressors varied by resource, the following generalized approach was used for all stressor/resource interactions:

- The frequency, duration, and spatial extent of exposure to stressors were analyzed for each resource. The frequency of exposure to stressors or frequency of a proposed activity was characterized as intermittent or continuous, and was quantified in terms of number per unit of time when possible. Duration of exposure was expressed as short or long term and was quantified in units of time (e.g., seconds, minutes, and hours) when possible. The spatial extent of exposure was generally characterized as widespread or localized, and the stressor footprint or area (e.g., square feet, square nautical miles) was quantified when possible.
- An analysis was conducted to determine whether and how resources are likely to respond to stressor exposure or be altered by stressor exposure based upon available scientific knowledge. This step included reviewing available scientific literature and empirical data. For many stressor/biological resource interactions, a range of likely responses or endpoints was identified. For example, exposure of an organism to sound produced by an underwater explosion could result in no response, a physiological response such as increased heart rate, a behavioral response such as being startled, or injury.
- The information obtained was used to analyze the likely impacts of individual stressors on a resource and to characterize the type, duration, and intensity (severity) of impacts. The type of impact was generally defined as beneficial or adverse and was further defined as a specific endpoint (e.g., change in behavior, mortality, change in concentration, loss of habitat. When possible, the endpoint was quantified. The duration of an impact was generally characterized as short term (e.g., minutes, days, weeks, months, depending on the resource), long term (e.g., months, years, decades, depending on the resource), or permanent. The intensity of an impact was then determined. For biological resources, the analysis started with individual organisms and their habitats, and then addressed populations, species, communities, and representative ecosystem characteristics, as appropriate.

3.0.5.4 Establishing Baseline for Analysis Comparison

As discussed in Section 2.4.3 (Alternatives Carried Forward), the proposed activities under each alternative are analyzed to determine the level and type of effect on the environment that could potentially result from these activities and are compared to the baseline level of activities. As an ongoing action, the baseline activities are reflected in the affected environment for each respective resource. This approach provides the analytical basis for establishing the scientific baseline when comparing the predicted effects of each alternative considered in this EIS/OEIS, as the potential future environmental condition of a resource because of an action. Section 1.7.4 (Related Environmental Documents) provides a list and description of the source documents informing this baseline and incorporated by reference where applicable. Previous environmental analyses of the baseline activity levels are overly conservative, given that the current actual levels of activity are well below levels of those analyzed in each of the documents. Activities that comprise the current operational baseline are defined as the average of representative activities over the most recent eight-year span reported in the TRMS database (from 2011 to 2018).

The following sections provide details on the stressors for purposes of analyzing potential impacts on marine-related biological resources. Generally, the stressors described below include acoustic (aircraft, vessel, and weapons noise), physical, energy, explosive, entanglement, ingestion, and secondary stressors.

3.0.5.5 Acoustic Stressors

This section describes acoustic stressors resulting from the main anthropogenic sources of noise in the PMSR Study Area, including contribution to those stressors and background noise as a result of testing and training activities. This provides the baseline information for analysis of acoustic impacts on resources in the remainder of this chapter. Anthropogenic noise is defined as noise originating from human activity and is generated from a variety of sources. These sources include commercial shipping, oil and gas exploration and production activities, commercial and recreational fishing (including fish finding sonar, fathometers, and acoustic deterrent and explosive harassment devices), whale watching activities, and general recreational boating. Characteristics of these sound sources are described in the following sections.

3.0.5.5.1 Vessel Noise

Commercial vessel noise, in particular commercial shipping, is a major contributor to noise in the ocean and predominates in nearshore transit lanes, such as those leading through the PMSR Study Area (Hildebrand et al., 2011; Hildebrand et al., 2012; McKenna et al., 2015; McKenna et al., 2012; Redfern et al., 2017). Frisk (2012) reported that, between 1950 and 2007, ocean noise in the 25–50 hertz (Hz) frequency range has increased 3.3 decibels (dB) per decade, resulting in a cumulative increase of approximately 19 dB over a baseline of 52 dB. The increase in noise is associated with an increase in commercial shipping, which correlates with global economic growth (Frisk, 2012). The charted commercial vessel Traffic Separation Scheme's lanes leading into the San Pedro Channel run through the central portions of the PMSR and serve as the entrance and exit points for the ports of Los Angeles and Long Beach. Civilian shipping distribution such as cargo and bulk carrier traffic dominates much of the offshore areas, including routes to and from Asia and the Panama Canal or South America.

As indicated by Figure 3.0-1, commercial vessel traffic flowing through the PMSR Study Area is mainly associated with the ports of Los Angeles and Long Beach.

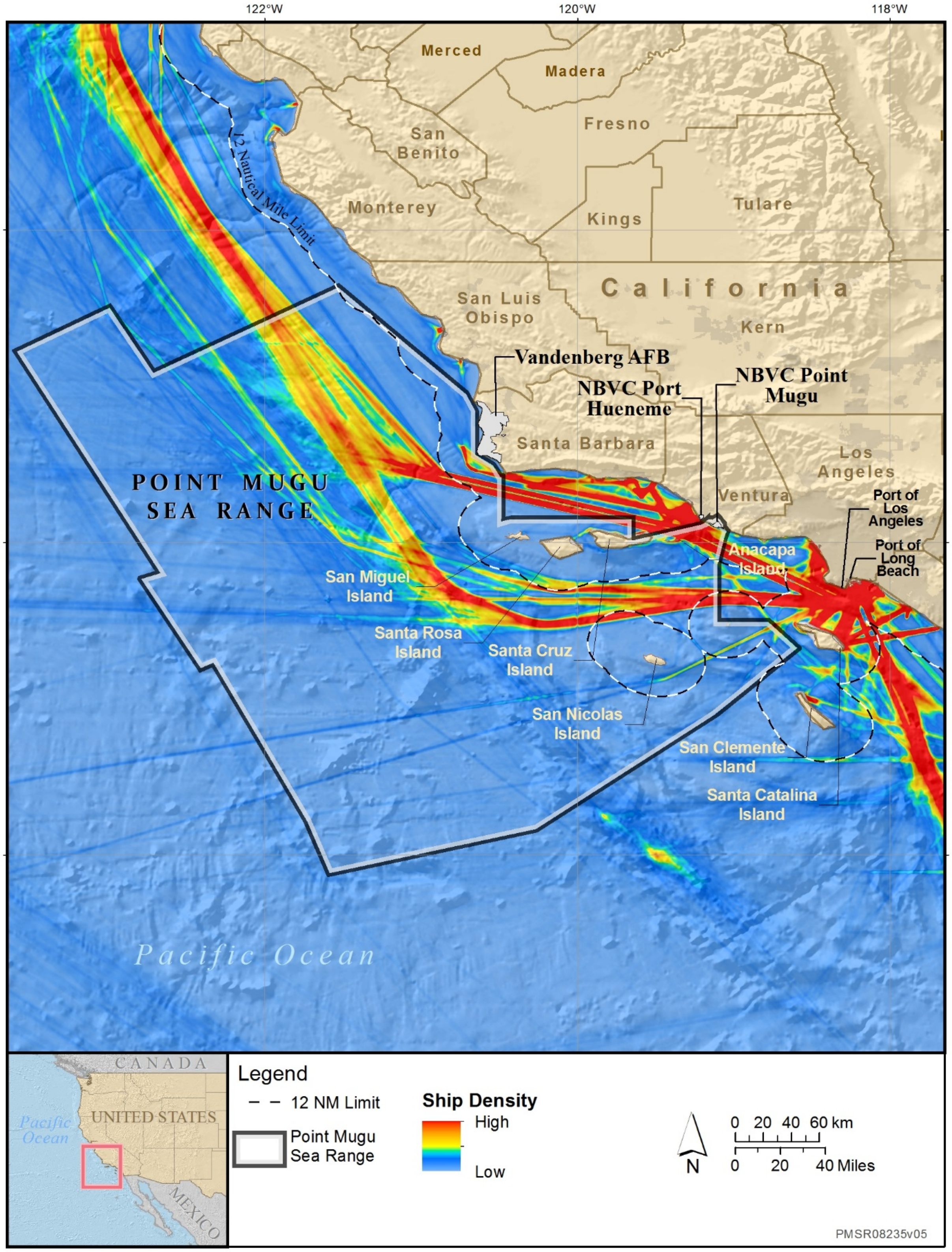

Figure 3.0-1: Relative Distribution of Commercial Vessel Traffic in the Point Mugu Sea Range Study Area

These two ports are adjacent to one another, and together they form the busiest commercial port hub in the United States and the sixth-busiest commercial port traffic in the world (Port of Los Angeles, 2017). Data from the ports of Los Angeles/Long Beach indicate there are on average in excess of approximately 7,000 commercial vessel transits per year associated with visits to just those ports (American Association of Port Authorities, 2017; McKenna et al., 2015; McKenna et al., 2012; Port of Los Angeles, 2017; U.S. Army Corps of Engineers, 2017). This large number of vessel port calls at Los Angeles/Long Beach does not account for a substantial number of additional commercial and recreational vessels transiting offshore of Point Mugu that may have stopped at or be bound for other major U.S. ports such as Seattle/Tacoma or San Francisco. Those vessels are otherwise only transiting through the PMSR Study Area and therefore are not part of the overall port statistics.

Data gathered between 2009 and 2012 from an acoustic monitoring site near Santa Barbara Island indicate the types and regularity of sounds contributing to ambient noise in the region (Hildebrand et al., 2012). Vessel noise was continuous but varied within each day at this offshore monitoring location. The trend noted was for increasing noise in the morning until a peak at approximately 6:00 a.m., dropping off back in the afternoon, and then increasing again at approximately 6:00 p.m., which reflected the preference in ship arrival and departure times at the Los Angeles/Long Beach ports located to the east-northeast of the monitoring site (Hildebrand et al., 2012).

Unlike the deep water monitoring site next to Santa Barbara Island where distant low-frequency vessel noise dominates ambient noise levels, in nearshore locations it is the much closer proximity to vessels and enhanced local sound propagation conditions[1] (including shallow water and hardened marine infrastructure) that are important (McKenna et al., 2012).

Hydrophone recordings from October to November 2008 and March to October 2009 for 593 container ships transiting in the Traffic Separation Scheme lanes for large commercial vessels going to and from the Ports of Los Angeles and Long Beach were used to estimate the source levels for vessels using those ports (McKenna et al., 2013). Source levels from vessels were found to range from 177 dB to 194 dB re 1 micropascal squared at 1 meter (m) over the frequency spectrum of 20−1,000 Hz (McKenna et al., 2013). These measured vessel source levels documented off Los Angeles and Long Beach are consistent with similar measurements and modeling of vessel source levels at various locations subject to intense commercial vessel traffic (Bassett et al., 2012; Erbe et al., 2012; Erbe et al., 2014; Jones et al., 2017; McKenna et al., 2012; Pine et al., 2016).

However, within the PMSR, Navy vessels represent a small amount of overall vessel traffic and an even smaller amount of overall vessel traffic noise. Navy ships make up only 4 percent of total ship traffic in Southern California (Table 3.0-1) (Mintz, 2016). In terms of anthropogenic noise, Navy ships are engineered to be as quiet as possible given ship class limitations, and would contribute a correspondingly smaller amount of shipping noise compared to more common commercial shipping and boating (Mintz, 2012; Mintz & Filadelfo, 2011). Exposure to vessel noise would be greatest in the areas of highest vessel traffic.

[1] Underwater acoustic monitoring in nearshore areas (Bassett et al., 2012; Erbe, 2002; Erbe et al., 2012; Erbe et al., 2016; Erbe et al., 2014; McKenna et al., 2012; McKenna et al., 2016; McKenna et al., 2013; Williams et al., 2009) have generally included a broader frequency spectrum than at deep water sites and, as a result, provide a record that includes the mid- and high-frequency range of sound associated with vessel noise.

Table 3.0-1: Interpolated Ship-Hours from 2011 to 2015 Positional Records in the Study Area

Ship Category	Southern California	Percentage of Total Ship Hours
Nonmilitary	27,223,000	96
U.S. Navy	1,076,000	4
U.S. Coast Guard	138,000	<1
Foreign Military	56,000	<1
Total	28,493,000	100

Note: Interpolated SeaLink data from 2011 through 2015, which represents an unknown fraction of actual vessel traffic. This data represents a relative traffic level, not absolute ship presence (Mintz, 2016).

While commercial traffic (and, therefore, broadband noise generated by it) is relatively steady throughout the year, Navy traffic is episodic in the ocean. Vessels engaged in testing and training may consist of a single vessel involved in an activity for a few hours or multiple vessels involved in a series of events that could last several weeks within a given area. Activities involving vessel movements occur intermittently and are variable in duration. Navy vessels do contribute to the overall increased ambient noise in inland waters, although their contribution to the overall noise in these environments is a small percentage compared to the large amounts of commercial and recreational vessel traffic in these areas (Mintz & Filadelfo, 2011). Navy surface combatants (such as guided missile destroyers and cruisers) and, to a lesser extent, submarines make up a large part of Navy traffic but contribute little noise to the overall sound budget of the oceans as these vessels are designed to be quiet to minimize detection. (Mintz & Filadelfo, 2011).

A variety of smaller craft that vary in size and speed, such as service vessels for routine operations and opposition forces used during testing and training events, would be operating within the Study Area.

Studies to determine traffic patterns of Navy and non-Navy vessels in the Study Area were conducted by the Center for Naval Analyses (Mintz, 2012; Mintz & Filadelfo, 2011; Mintz & Parker, 2006). The most recent analysis covered the period 2011–2015 (Mintz, 2016) and included U.S. Navy surface ship traffic and non-military vessels such as cargo vessels, bulk carriers, commercial fishing vessels, oil tankers, passenger vessels, tugs, and research vessels. Caveats to this analysis include that only vessels over 65 feet (ft.) in length are reported, so smaller Navy vessels and civilian craft are not included, and vessel position records are much more frequent for Navy vessels than for commercial vessels. Therefore, the Navy is likely overrepresented in the data and the reported fraction of total energy is likely the upper limit of its contribution (Mintz, 2012; Mintz & Filadelfo, 2011).

During testing and training, speeds of most large naval vessels (greater than 60 ft.) generally range from 10 to 15 knots to limit fuel consumption; however, on occasion, ships will operate at higher speeds within their specific operational capabilities. Mintz (2016) reported median speeds for U.S. Navy vessel and various commercial ship classes (Table 3.0-2) in Southern California from 2011 to 2015. Radiated noise from ships varies depending on the nature, size, and speed of the ship. Due to the large number of variables that determine the sound level radiated from vessels, this source will be analyzed qualitatively. The quietest Navy warships radiate much less broadband noise than a typical fishing vessel, while the loudest Navy ships during travel are almost on par with large oil tankers (Mintz & Filadelfo, 2011). For comparison, McKenna et al. (2012) determined that container ships transiting Southern California produced broadband source levels around 188 decibels referenced to 1 micropascal (dB re 1 µPa), and a typical fishing vessel radiates noise at a source level of about 158 dB re 1 µPa (Mintz & Filadelfo, 2011).

Table 3.0-2: Median Surface Ship Speeds for Southern California 2011–2015

Ship Class	Median Ship Speed (knots)
U.S. Navy Aircraft Carrier	15.6
U.S. Navy Cruiser or Destroyer	11.0–11.8
U.S. Navy Amphibious Assault Ship	8.8–11.1
Commercial Cargo Ship	13.4
Commercial Tanker	11.6
Passenger Ship	8.1

The average acoustic signature for a Navy vessel is 163 dB re 1 µPa, while the average acoustic signature for a commercial vessel is 175 dB re 1 µPa (Mintz & Filadelfo, 2011). Typical large vessel ship-radiated noise is dominated by tonals related to blade and shaft sources at frequencies below 50 Hz and by broadband components related to cavitation and flow noise at higher frequencies (approximately around the one-third octave band centered at 100 Hz) (Mintz & Filadelfo, 2011). Ship types also have unique acoustic signatures characterized by differences in dominant frequencies. Bulk carrier noise is predominantly near 100 Hz, while container ship and tanker noise is predominantly below 40 Hz (McKenna et al., 2012). Small craft will emit higher frequency noise (between 1 kilohertz [kHz] and 50 kHz) than larger ships (below 1 kHz). Sound produced by vessels will typically increase with speed.

3.0.5.5.2 Explosives and Noise Resulting from Fishing Activities

In waters off Southern California, Washington, and Alaska, passive acoustic monitoring efforts since 2009 have documented the routine use of non-military explosives at-sea (Baumann-Pickering et al., 2013; Debich et al., 2014; Debich et al., 2015; Kerosky et al., 2013; Rice et al., 2015; Rice et al., 2017; Rice et al., 2018; Širović et al., 2016; Širović et al., 2012; Trickey et al., 2015; Wiggins et al., 2017; Wiggins et al., 2018). Based on the spectral properties of the recorded sounds, their correspondence with known fishing seasons or activity, and their occurrence at night when the Navy does not conduct activities using explosives, the source of these explosions has been linked to the use of explosive marine mammal deterrents, which as a group are commonly known as "seal bombs" (Wiggins et al., 2018). Seal bombs are intended to be used by commercial fishers to deter marine mammals, particularly pinnipeds, from preying upon their catch and to prevent marine mammals from interacting and potentially becoming entangled with fishing gear (Bland, 2015; National Marine Fisheries Service, 2015; Schakner & Blumstein, 2013).

In Southern California, several fisheries, including squid, purse seine, and set gillnet fisheries, use seal bombs as legal deterrents (Baumann-Pickering et al., 2013; Bland, 2017; National Marine Fisheries Service, 2015). Based on the number of explosions recorded over the last decade in Southern California, Washington, and Alaska, the use of seal bombs is much more prevalent than might be expected by the public. For example, in the seven months from May to November 2013, over 24,000 explosions identified as seal bombs were recorded at a passive acoustic monitoring site (Site "M") located to the northeast of SNI (Debich et al., 2015). By comparison, in the 12-month period from August 2012 to August 2013, there were fewer than 400 underwater explosions resulting from Navy activities in the Southern California Training Range (Baumann-Pickering et al., 2013). In the time period between June 2012 and June 2017 at a site to the south of SNI, there have been an average of 9,514 explosions detected per year at that one site (Wiggins et al., 2018). Although the average use at an individual monitoring site varies within the year based on start and end of the fishing season and between sites based on shifts in fishing effort to the north and south, the data records from passive acoustic monitoring along the U.S. Pacific coast, as cited above, indicates widespread and routine use of explosive marine mammal deterrent devices, including in the PMSR Study Area.

Echosounder pings, most often used in the area for fish detection or as a depth-finder to aid navigation, were also present in the acoustic record (Hildebrand et al., 2012).

3.0.5.5.3 Petroleum Exploration and Extraction

In many areas of the world, including the PMSR Study Area, oil and gas seismic exploration in the ocean is undertaken using a group of air guns towed behind large research vessels. The air guns convert high-pressure air into very strong shock wave impulses (analogous to underwater explosions) that are designed to reflect pressure waves off the seafloor and the various buried layers of sediment under the seafloor. Seismic exploration surveys last many days and cover vast overlapping swaths of the ocean area being explored. Most of the impulse energy produced by these air guns is heard as low-frequency sound, which can travel long distances and contributes to underwater ambient noise. This and other petroleum exploration and extraction related activities are a concern due to the chronic noise they may produce (Erbe et al., 2013; Erbe & McPherson, 2017). In January 2018, the Department of Interior issued a Draft Proposed Program to offer lease sales under the National Outer Continental Shelf Oil and Gas Leasing Program, which includes potentially seven leases in Pacific (one in Southern California). There are already 43 leases in producing status in the Southern California Planning area, which could increase activity and also impact ocean noise levels. Currently, in the nearshore waters of the Santa Barbara Channel in the central portion of the PMSR, there are already 15 active offshore oil and gas production facilities and another seven farther to the south off the Long Beach area (Bureau of Ocean Energy Management, 2012).

3.0.5.5.4 Aircraft Noise

In the vicinity of NBVC Point Mugu, there is civilian and commercial aircraft activity, under the control of the Los Angeles Air Route Traffic Control Center, that normally flies on formal airway route structures at both low and high altitudes. These airways run along the coastline and to various points east. The airways running parallel along the coast are among the most heavily used in the area. The majority of commercial and general aviation aircraft noise would be generated from flights going in and out of the regional airports in the area (Santa Barbara Airport, Oxnard Airport, and Camarillo Airport).

Fixed-wing, tiltrotor, and rotary-wing aircraft are used for a variety of testing and training activities throughout the Study Area, contributing both airborne and underwater sound to the ocean environment. Sounds in air are often measured using A-weighting, which adjusts received sound levels based on human hearing abilities. Aircraft used in testing and training generally have turboprop or jet engines. Motors, propellers, and rotors produce the most noise, with some noise contributed by aerodynamic turbulence. Aircraft sounds have more energy at lower frequencies. Aircraft may transit to or from vessels at sea throughout the Study Area from established airfields. The majority of aircraft noise would be generated at NBVC Point Mugu airfield, which is immediately adjacent to the Study Area. Takeoffs and landings occur as well on vessels across the Study Area. Takeoffs and landings from Navy vessels produce in-water noise for a brief period as the aircraft climbs to cruising altitude. Military activities involving aircraft generally are dispersed over large expanses of open ocean but can be highly concentrated in time and location. Table 3.0-3 provides source levels for some typical aircraft used in the Study Area and depicts comparable airborne source levels for the F-35, EA-18G, and F/A-18 during takeoff.

Table 3.0-3: Representative Aircraft Sound Characteristics

Noise Source	Sound Pressure Level
In-Water Noise Level	
F/A-18 Subsonic at 1,000 ft. (300 m) Altitude	152 dB re 1 µPa at 2 m below water surface[1]
F/A-18 Subsonic at 10,000 ft. (3,000 m) Altitude	128 dB re 1 µPa at 2 m below water surface[1]
H-60 Helicopter Hovering at 82 ft. (25 m) Altitude	Approximately 125 dB re 1 µPa at 1 m below water surface[2*]
Airborne Noise Level	
F/A-18 Under Military Power	143 dBA re 20 µPa at 13 m from source[3]
F/A-18 Under Afterburner	146 dBA re 20 µPa at 13 m from source[3]
F-35 Under Military Power	145 dBA re 20 µPa at 13 m from source[3]
F-35 Under Afterburner	148 dBA re 20 µPa at 13 m from source[3]
H-60 Helicopter Hovering at 82 ft. (25 m) Altitude	113 dBA re 20 µPa at 25 m from source[2]
H-65 Helicopter Hovering at 82 ft. (25 m) Altitude	113 dBA re 20 µPa at 25 m from source[2**]
F-35 Takeoff Through 1,000 ft. (300 m) Altitude	119 dBA re 20 $\mu Pa^2 s$[4***] (per second of duration)
EA-18G Takeoff Through 1,622 ft. (500 m) Altitude	115 dBA re 20 $\mu Pa^2 s$[5**] (per second of duration)

Sources: [1]Eller and Cavanagh (2000) [2]Bousman and Kufeld (2005); [3]U.S. Naval Research Advisory Committee (2009), [4]U.S. Department of the Air Force (2016), [5]U.S. Department of the Navy (2012)
* estimate based on in-air level
**modeled at the greater H-60 level
***average sound exposure level
Notes: dB re 1 µPa = decibel(s) referenced to 1 micropascal, dBA re 20 µPa = A-weighted decibel(s) referenced to 20 micropascals, m = meter(s), ft. = feet

3.0.5.5.4.1 Underwater Transmission of Aircraft Noise

Sound generated in air transmits to water primarily in a narrow area directly below the source. A sound wave propagating from any source must enter the water at an angle of incidence of about 13 degrees (°) or less from the vertical for the wave to continue propagating under the water's surface. At greater angles of incidence, the water surface acts as an effective reflector of the sound wave and allows very little penetration of the wave below the water (Urick, 1983). Water depth and bottom conditions strongly influence how the sound from airborne sources propagates underwater. At lower altitudes, sound levels reaching the water surface would be higher, but the transmission area would be smaller. As the sound source gains altitude, sound reaching the water surface diminishes, but the possible transmission area increases. Estimates of underwater sound pressure level are provided for representative aircraft in Table 3.0-3.

Noise generated by fixed-wing aircraft is transient in nature and extremely variable in intensity. Most fixed-wing aircraft sorties (a flight mission made by an individual aircraft) would occur above 3,000 ft. Air combat maneuver altitudes generally range from 5,000 to 30,000 ft. above ground level, and typical airspeeds range from very low (less than 200 knots) to high subsonic (less than 600 knots). Sound exposure levels at the sea surface from most air combat maneuver overflights are expected to be less than 85 A-weighted decibels (based on an F/A-18 aircraft flying at an altitude of 5,000 ft. above ground level and at a subsonic airspeed [400 knots]) (U.S. Department of the Navy, 2016). Exposure to fixed-wing aircraft noise would be brief (seconds) as an aircraft quickly passes overhead.

3.0.5.5.4.2 Helicopters

Noise generated from helicopters is transient in nature and extremely variable in intensity. In general, helicopters produce lower-frequency sounds and vibration at a higher intensity than fixed-wing aircraft (Richardson et al., 1995). Helicopter sounds contain dominant tones from the rotors that are generally below 500 Hz. Helicopters often radiate more sound forward than backward. The underwater noise produced is generally brief when compared with the duration of audibility in the air and is estimated to be 125 dB re 1 µPa at 1 m below the water surface for an H-60 hovering at 82 ft. (25 m) altitude (Bousman & Kufeld, 2005).

3.0.5.5.4.3 Sonic Booms

An intense but infrequent type of aircraft noise is the sonic boom, produced when an aircraft exceeds the speed of sound. Supersonic aircraft flights are not intentionally generated below 30,000 ft. unless over water and more than 30 nautical miles (NM) from inhabited coastal areas or islands. However, deviation from these guidelines may be authorized for tactical missions that require supersonic flight, phases of formal training requiring supersonic speeds, research and test flights that require supersonic speeds, and for flight demonstration purposes when authorized by the Chief of Naval Operations (U.S. Department of the Navy, 2016).

Several factors that influence sonic booms include weight, size, and shape of aircraft or vehicle; altitude; flight paths; and atmospheric conditions. A larger and heavier aircraft must displace more air and create more lift to sustain flight, compared with small, light aircraft. Therefore, larger aircraft create sonic booms that are stronger than those of smaller, lighter aircraft. Consequently, the larger and heavier the aircraft, the stronger the shock waves (U.S. Department of the Navy & Department of Defense, 2007). Aircraft maneuvers that result in changes to acceleration, flight path angle, or heading can also affect the strength of a boom. In general, an increase in flight path angle (lifting the aircraft’s nose) will diffuse a boom while a decrease (lowering the aircraft’s nose) will focus it. In addition, acceleration will focus a boom while deceleration will weaken it. Any change in horizontal direction will focus a boom, causing two or more wave fronts that originated from the aircraft at different times to coincide exactly (U.S. Department of the Navy, 2001). Atmospheric conditions such as wind speed and direction, and air temperature and pressure, can also influence the sound propagation of a sonic boom.

Of all the factors influencing sonic booms, increasing altitude is the most effective method of reducing sonic boom intensity. The width of the boom “carpet,” or area exposed to sonic boom beneath an aircraft, is about 1 mile (mi.) for every 1,000 ft. of altitude. For example, an aircraft flying supersonic, straight, and level at 50,000 ft. can produce a sonic boom carpet about 50 mi. wide. The sonic boom, however, would not be uniform, and its intensity at the water surface would decrease with greater aircraft altitude. Maximum intensity is directly beneath the aircraft and decreases as the lateral distance from the flight path increases, until shock waves refract away from the ground or water surface and the sonic boom attenuates. The lateral spreading of the sonic boom depends only on altitude, speed, and the atmosphere and is independent of the vehicle’s shape, size, and weight. The ratio of the aircraft length to the maximum cross-sectional area also influences the intensity of the sonic boom. The longer and slenderer the aircraft, the weaker the shock waves. The wider and blunter the aircraft, the stronger the shock waves can be (U.S. Department of the Navy & Department of Defense, 2007).

In air, the energy from a sonic boom is concentrated in the frequency range from 0.1 to 100 Hz. The underwater sound field due to transmitted sonic boom waveforms is primarily composed of low-frequency components (Sparrow, 2002), and frequencies greater than 20 Hz have been found to be difficult to observe at depths greater than 33 ft. (10 m) (Sohn et al., 2000). F/A-18 Hornet supersonic flight was modeled to obtain peak sound pressure levels (SPLs) and energy flux density at the water surface and at depth (U.S. Department of the Air Force, 2000). These results are shown in Table 3.0-4.

Table 3.0-4: Sonic Boom Underwater Sound Levels Modeled for F/A-18 Hornet Supersonic Flight

Mach Number*	Aircraft Altitude (km)	Peak SPL (dB re 1 µPa)			Energy Flux Density (dB re 1 µPa²-s)[1]		
		At surface	50 m Depth	100 m Depth	At surface	50 m Depth	100 m Depth
1.2	1	176	138	126	160	131	122
	5	164	132	121	150	126	117
	10	158	130	119	144	124	115
2	1	178	146	134	161	137	128
	5	166	139	128	150	131	122
	10	159	135	124	144	127	119

[1]Equivalent to SEL for a plane wave.
*Mach number equals aircraft speed divided by the speed of sound.
Notes: SPL = sound pressure level, dB re 1 µPa = decibel(s) referenced to 1 micropascal, dB re 1 µPa²-s = decibel(s) referenced to 1 micropascal squared seconds, m = meter(s)

Table 3.0-5 shows the total number of flight operations (total number of sorties) that currently occurs within the PMSR and the number of activities proposed under each alternative.

Table 3.0-5: Total Number of Aircraft Activity Within the Point Mugu Sea Range

Activity	Baseline	Alternative 1	Alternative 2
Flight Operations (# of sorties)	3,934	5,288	4,822

3.0.5.5.5 Weapons Noise

Depending on the weapon, incidental (unintentional) noise may be produced at launch or firing, while in flight, or upon impact. Other devices intentionally produce noise to serve as a non-lethal deterrent (Table 3.0-6). Not all weapons utilize explosives, either by design or because they are non-explosive (inert) munitions.

Noise associated with large-caliber weapons firing and the impact of non-explosive inert munitions or kinetic weapons would typically occur at locations greater than 12 NM from shore in warning areas or special use airspace (SUA) for safety reasons. Small- and medium-caliber weapons firing could occur throughout the PMSR.

Table 3.0-6: Example Weapons Noise

Noise Source	Sound Level
In-Water Noise Level	
Naval Gunfire Muzzle Blast (5-inch)	Approximately 200 dB re 1 µPa peak directly under gun muzzle at 1.5 m below the water surface[1]
Airborne Noise Level	
Naval Gunfire Muzzle Blast (5-inch)	178 dB re 20 µPa peak directly below the gun muzzle above the water surface[1]
Hellfire Missile Launch from Aircraft	149 dB re 20 µPa at 4.5 m[2]
RIM 116 Surface-to-Air Missile	122–135 dBA re 20 µPa between 2 and 4 m from the launcher on shore[3]
Tactical Tomahawk Cruise Missile	92 dBA re 20 µPa 529 m from the launcher on shore[3]

Sources: [1]Yagla and Stiegler (2003), [2]U.S. Department of the Army (1999), [3]U.S. Department of the Navy (2013)
Notes: dB re 1 µPa = decibel(s) referenced to 1 micropascal, dB re 20 µPa = decibel(s) referenced to 20 micropascals, dBA re 20 µPa = A-weighted decibel(s) referenced to 20 micropascals, m = meter(s)

3.0.5.5.5.1 Muzzle Blast from Naval Gunfire

Firing a gun produces a muzzle blast in air that propagates away from the gun with the strongest directivity in the direction of fire (Figure 3.0-2). Because the muzzle blast is generated at the gun, the noise decays with distance from the gun. The muzzle blast has been measured for the largest gun analyzed in this EIS/OEIS, the 5-inch (in.) large-caliber naval gun. At a distance of 3,700 ft. from the gun, which was fired at 10° elevation angle, and at 10° off the firing line, the in-air received level was 124 dB re 20 µPa SPL peak for the atmospheric conditions of the test (U.S. Department of the Navy, 1981). Measurements were obtained for additional distances and angles off the firing line, but were specific to the atmospheric conditions present during the testing.

As the pressure from the muzzle blast from a ship-mounted large-caliber gun propagates in air toward the water surface, the pressure can be both reflected from the water surface and transmitted into the water. Most sound enters the water in a narrow cone beneath the sound source (within about 13–14° of vertical), with most sound outside of this cone being totally reflected from the water surface. In-water sound levels were measured during the muzzle blast of a 5 in. large-caliber naval gun. The highest possible sound level in the water (average peak SPL of 200 dB re 1 µPa, measured 5 ft. below the surface) was obtained when the gun was fired at the lowest angle, placing the blast closest to the water surface (Yagla & Stiegler, 2003). The unweighted sound exposure level would be expected to be 15–20 dB lower than the peak pressure, making the highest possible sound exposure level in the water about 180–185 dB re 1 µPa squared seconds directly below the muzzle blast. Other gunfire arrangements, such as with smaller caliber weapons or greater angles of fire, would result in less sound entering the water. The sound entering the water would have the strongest directivity directly downward beneath the gun blast, with lower sound pressures at increasing angles of incidence until the angle of incidence is reached where no sound enters the water.

Source: Yagla & Stiegler (2003)

Figure 3.0-2: Gun Blast and Projectile from a 5" 54/62 Navy Gun

Large-caliber gunfire also sends energy through the ship structure and into the water. This effect was investigated in conjunction with the measurement of 5 in. gun firing described above. The energy transmitted through the ship to the water for a typical round was about 6 percent of that from the muzzle blast impinging on the water (U.S. Department of the Navy, 2000). Therefore, sound transmitted from the gun through the hull into the water is a minimal component of overall weapons firing noise.

3.0.5.5.5.2 Supersonic Projectile Bow Shock Wave

Supersonic projectiles, such as a fired gun shell or kinetic energy weapon, create a bow shock wave along the line of fire. A bow shock wave is an impulsive sound caused by a projectile exceeding the speed of sound. The bow shock wave itself travels at the speed of sound in air. The projectile bow shock wave created in air by a shell in flight at supersonic speeds propagates in a cone (generally about 65°) behind the projectile in the direction of fire (U.S. Department of the Navy, 1981). Exposure to the bow shock wave is very brief.

Projectiles from a 5 in. 54/62 caliber gun would travel at approximately 2,600 ft./second, and the associated bow shock wave is subjectively described as a “crack” noise (U.S. Department of the Navy, 1981). Measurements of a 5 in. projectile shock wave ranged from 140 to 147 dB re 20 µPa SPL peak taken at the ground surface at 0.59 NM distance from the firing location and 10° off the line of fire for safety (approximately 190 m from the shell’s trajectory) (U.S. Department of the Navy, 1981).

Hyperkinetic projectiles may travel up to and exceed approximately six times the speed of sound in air, or about 6,500 ft./second. For a hyperkinetic projectile sized similar to the 5 in. shell, peak pressures would be expected to be several dB higher than those described for the 5 in. projectile above, following the model in U.S. Department of the Navy (1981).

Like sound from the gun muzzle blast, sound waves from a projectile in flight could only enter the water in a narrow cone beneath the sound source, with in-air sound being totally reflected from the water surface outside of the cone. The region of underwater sound influence from a single traveling shell would be relatively narrow, and the duration of sound influence would be brief at any location.

3.0.5.5.5.3 Launch Noise

Missiles and targets can be rocket or jet propelled, and are launched from shore, vessels, or aircraft in PMSR SUA (such as warning areas, air traffic control, and restricted areas). Target launches are done from launch facilities on Point Mugu and SNI, as well as air launched from PMSR support aircraft. Sound due to missile and target launches is typically at a maximum at initiation of the booster rocket. It rapidly fades as the missile or target reaches optimal thrust conditions, and the missile or target reaches a downrange distance where the booster burns out and the sustainer engine continues. Examples of weapons launch noise sound levels are shown in Table 3.0-6.

3.0.5.5.5.4 Impact Noise (Non-Explosive)

Any object dropped in the water would create a noise upon impact, depending on the object's size, mass, and speed. Sounds of this type are produced by the kinetic energy transfer of the object with the target surface and are highly localized to the area of disturbance. A significant portion of an object's kinetic energy would be lost to splash, any deformation of the object, and other forms of non-mechanical energy (McLennan, 1997). The remaining energy could contribute to sound generation. Most objects would be only momentarily detectable, if at all, but some large objects traveling at high speeds could generate a broadband impulsive sound upon impact with the water surface. Sound associated with impact events is typically of low frequency (less than 250 Hz) and of short duration.

3.0.5.6 Explosive Stressors

This section describes the characteristics of explosions during weapons firing. It also provides the basis for analysis of explosive impacts on resources in the remainder of this chapter.

The near-instantaneous rise from ambient to an extremely high peak pressure is what makes an explosive shock wave potentially damaging. Farther from an explosive, the peak pressures decay and the explosive waves propagate as an impulsive, broadband sound. Several parameters influence the effect of an explosive: the weight of the explosive warhead; the type of explosive material; the boundaries and characteristics of the propagation medium; and, in water, the detonation depth. The net explosive weight, which is the explosive power of a charge expressed as the equivalent weight of trinitrotoluene (TNT), accounts for the first two parameters.

Missiles, rockets, bombs, and medium- and large-caliber projectiles may be explosive or non-explosive (i.e., inert), depending on the objective of the testing or training activity in which they are used. Explosive detonations during testing and training activities are associated with the above-listed munition types. Testing of and training with high-explosive munitions that could detonate, in the air or at or near the water's surface, sends energy into the water and could result in potential impacts on marine species. Most testing or training with explosives would occur greater than 3 NM from shore.

The explosives quantitatively analyzed for impacts on protected species are shown in Table 3.0-7. The Navy uses some very small impulsive sources (less than 0.1 pound net explosive weight), categorized in bin E0, which are not anticipated to result in takes of protected species. Quantitative modeling in multiple locations has validated that these sources have a very small zone of influence. These E0 charges, therefore, are categorized as *de minimis* sources and are qualitatively analyzed to determine the appropriate effects conclusions under the National Environmental Policy Act in the appropriate resource impact analyses, as well as under the MMPA and the ESA. As noted previously, the majority of munitions used are inert; however, explosive munitions such as bombs, rockets, and missiles detonate either in-air against an aerial target, just above the surface against a surface target, or, in some cases, at the water's surface.

Table 3.0-7: Explosive Sources Quantitatively Analyzed

Bin	Net Explosive Weight (pounds [lb.])	Example Explosive Source	Baseline		No Action Alternative		Alternative 1		Alternative 2	
			Annual	7-year Total	Annual	7-year Total	Annual	7-year Total	Annual	7-year Total
E1	0.1–0.25	Medium-caliber projectiles	1,121	7,847	0	0	22,110	154,770	7,800	54,600
E3	> 0.5–2.5	Large-caliber projectiles	833	5,831	0	0	4,909	34,363	1,257	8,799
E5	> 5–10	5 in. projectile/ 2.75" rockets	110	770	0	0	1,690	11,830	131	916
E6	> 10–20	Hellfire missile	30	210	0	0	72	504	28	196
E7	> 20–60	HARM missile	37	259	0	0	45	315	131	917
E8	> 60–100	Standard missile	30	210	0	0	45	315	56	392
E9	> 100–250	500 lb. bomb	49	343	0	0	58	406	40	280
E10	> 250–500	Harpoon missile	3	21	0	0	13	91	3	21

Notes: HARM = High-speed Anti-Radiation Missile, > = greater than. The increase in tempo under each Alternative is mostly a result of an increase in Combat Systems Ship Qualification Trials, as discussed in Section 2.1.1 (Primary Mission Areas).

Propagation of explosive pressure waves in water is highly dependent on environmental characteristics such as bathymetry, bottom type, water depth, temperature, and salinity, which affect how the pressure waves are reflected, refracted, or scattered; the potential for reverberation; and interference due to multi-path propagation. In addition, absorption greatly affects the distance over which higher frequency components of explosive broadband noise can propagate. Because of the complexity of analyzing sound propagation in the ocean environment, the Navy relies on acoustic models in its environmental analyses that consider sound source characteristics and varying ocean conditions across the Study Area.

3.0.5.6.1 Explosions in Air

Explosions in air include detonations of projectiles and missiles during surface-to-air gunnery and air-to-air missile exercises conducted during air warfare. These explosions typically occur far above the water surface in SUA. Some typical types of explosive munitions that would be detonated in air during Navy activities are shown in Table 3.0-8.

Table 3.0-8: Typical Air Explosive Munitions During Navy Activities

Weapon Type[1]	Net Explosive Weight (lb.)	Typical Altitude of Detonation (ft.)
Surface-to-Air Missile		
RIM-66 SM-2 Standard Missile	80	> 15,000
RIM-116 Rolling Airframe Missile	39	< 3,000
RIM-162 Evolved Sea Sparrow (ESSM)	36	> 15,000 (can be used on low targets)
AGM-114 Hellfire	18	< 3,000
Air-to-Air Missile		
AIM-9 Sidewinder	38	> 15,000
AIM-120 AMRAAM	17	> 15,000
Projectile – Large- Caliber[2,3]		
5”54/62 caliber HE-ET	7	< 100
5”54/62 caliber Other	8	< 3,000

[1]Mission Design Series and popular name shown for missiles.
[2]Most medium- and large-caliber projectiles used during Navy testing and training activities do not contain high explosives.
[3]Used against an air target (>100 feet above water surface)
Notes: AMRAAM = Advanced Medium-Range Air-to-Air Missile, HARM = High-Speed Anti-Radiation Missile, HE-ET = High Explosive-Electronic Time, > = greater than, < = less than

Missiles, bombs, rockets, and projectiles that detonate at or near the water surface, which are considered for underwater impacts, would also release some explosive energy into the air. The explosive energy released by detonations in air has been well studied, and basic methods are available to estimate the explosive energy exposure with distance from the detonation (e.g., (U.S. Department of the Navy, 1975)). In air, the propagation of impulsive noise from an explosion is highly influenced by atmospheric conditions, including temperature and wind. While basic estimation methods do not consider the unique environmental conditions that may be present on a given day, they allow for approximation of explosive energy propagation under neutral atmospheric conditions. Explosions that occur during air warfare would typically be at a sufficient altitude that a large portion of the sound refracts upward due to cooling temperatures with increased altitude.

Missiles, rockets, projectiles, and other cased weapons will produce casing fragments upon detonation. These fragments may be of variable size and are ejected at supersonic speed from the detonation. The casing fragments will be ejected at velocities much greater than debris from any target due to the proximity of the casing to the explosive material. Unlike detonations on land targets, in-air detonations during Navy testing and training would not result in other propelled materials such as crater debris.

3.0.5.7 Energy Stressors

This section describes the characteristics of energy introduced through naval testing and training activities, and the relative magnitude and location of these activities, to provide the basis for analysis of potential impacts on resources from in-air electromagnetic devices, and lasers.

Directed energy (DE) can include light amplification by stimulated emission of radiation (laser) and high-power microwave systems. DE Test facilities are on the west end of SNI and are proposed for construction on NBVC Point Mugu, near Building 7020, to enhance DE testing on the PMSR. The DE test program requirement for operationally realistic engagements in both maritime and land environments with an over-the-ocean shot from a land-based shooter site to a land-based target was analyzed in separate Environmental Assessments (U.S. Department of the Navy, 2014, 2015).

3.0.5.7.1 In-Air Electromagnetic Devices

Sources of electromagnetic energy in the air include kinetic energy weapons, communications transmitters, radars, and electronic countermeasures transmitters. Electromagnetic devices on Navy platforms operate across a wide range of frequencies and power. On a single ship, the source frequencies may range from 2 megahertz to 14,500 megahertz, and transmitter maximum average power may range from 0.25 watts to 1,280,000 watts.

The term radar was originally coined by the Navy to refer to Radio Detection and Ranging. A radar system is an electromagnetic device that emits radio waves to detect and locate objects. In most cases, basic radar systems operate by generating pulses of radio frequency energy and transmitting these pulses via directional antennae into space (Courbis & Timmel, 2008). Some of this energy is reflected by the target back to the antenna, and the signal is processed to provide useful information to the operator.

Radars come in a variety of sizes and power, ranging from wide-band milliwatt systems to very-high-power systems that are used primarily for long-range search and surveillance (Courbis & Timmel, 2008). In general, radars operate at radio frequencies that range between 300 megahertz and 300 gigahertz and are often classified according to their frequency range. Navy vessels commonly operate radar systems that include S-band and X-band electronically steered radar. S-band radar serves as the primary search and acquisition sensor capable of tracking and collecting data on a large number of objects while X-band radar can provide high-resolution data on particular objects of interest and discrimination for weapons systems. Both systems employ a variety of waveforms and bandwidths to provide high-quality data collection and operational flexibility (Baird et al., 2016).

It is assumed that most Navy platforms associated with the Proposed Action will be transmitting from a variety of in-air electromagnetic devices at all times that they are underway, with very limited exceptions. Most of these transmissions (e.g., for routine surveillance, communications, and navigation) will be at low power. High-power settings are used for a small number of activities, including ballistic missile defense testing, missile and rocket testing, radar and other system testing, and signature analysis operations. The number of Navy vessels or aircraft in the Study Area at any given time varies and is dependent on testing requirements. Therefore, in-air electromagnetic energy as part of the Proposed Action would be widely dispersed throughout the Study Area.

3.0.5.7.1.1 Lasers

The devices discussed here include lasers (the maximum power of up to 1 megawatt and wavelengths from 180 nanometers to 14,000 nanometers) that can be organized into two categories: (1) low-energy lasers, and (2) high-energy lasers. Low-energy lasers are used to illuminate or designate targets, measure the distance to a target, guide weapons, and aid in communication. High-energy lasers are used as weapons to create critical failures on air and surface targets.

Low-Energy Lasers

Within the category of low-energy lasers, the highest potential level of exposure would be from an airborne laser beam directed at the ocean's surface. An assessment on the use of low-energy lasers by the Navy determined that low-energy lasers, including those involved in the testing and training activities in this EIS/OEIS, have an extremely low potential to impact marine biological resources (U.S. Department of the Navy, 2010). The assessment determined that the maximum potential for laser exposure is at the ocean's surface, where laser intensity is greatest (U.S. Department of the Navy, 2010). As the laser penetrates the water, 96 percent of a laser beam is absorbed, scattered, or otherwise lost (Ulrich, 2004). Based on the parameters of the low-energy lasers and the behavior and life history of major biological groups, it was determined the greatest potential for impact would be to the eye of a marine species. However, an animal's eye would have to be exposed to a direct laser beam for at least 10 seconds or longer to sustain damage. The U.S. Department of the Navy (2010) assessed the potential for damage based on species-specific eye/vision parameters and the anticipated output from low-energy lasers, and determined that no animals were predicted to incur damage. Therefore, low-energy lasers are not further analyzed in this document for possible impacts on biological resources.

High-Energy Lasers

High-energy laser weapons testing and training involves the use of DE as a weapon against small surface vessels and airborne targets. High-energy lasers would be employed from surface ships and/or land-based platforms, and are designed to create small but critical failures in potential targets. The high-energy laser is expected to be used at short ranges. Marine life at or near the ocean surface and birds could be susceptible to injury by high-energy lasers.

Table 3.0-9 shows the number of annual Directed Energy events for the baseline and proposed under each alternative.

Table 3.0-9: Number of Directed Energy Events

Activity	Baseline	Alternative 1	Alternative 2
Directed Energy	624*	624	624

*The Directed Energy baseline tempo is not based on the average amounts of actual historical use but rather on total events analyzed in various EAs since the 2002 EIS was completed. This is a newer activity for the PMSR, and there are no data available.

3.0.5.8 Physical Disturbance and Strike Stressors

This section describes the characteristics of physical disturbance and strike stressors from Navy testing and training activities. It also describes the magnitude and location of these activities to provide the basis for analyzing the potential physical disturbance and strike impacts on resources in the remainder of this chapter.

3.0.5.8.1 Vessels

Vessels used as part of the Proposed Action include ships (e.g., aircraft carriers, surface combatants), support craft, and submarines ranging in size from 15 ft. to over 1,000 ft. Navy ships transit at speeds that are optimal for fuel conservation or to meet operational requirements. Large Navy ships (greater than 18 m in length) generally operate at average speeds of 10–15 knots, and submarines generally operate at speeds in the range of 8–13 knots. Small craft (for purposes of this discussion, less than 18 m in length), which are all support craft, have much more variable speeds (0–50+ knots, dependent on the mission). While these speeds are considered averages and representative of most events, some vessels need to operate outside of these parameters. For example, to produce the required relative wind speed over the flight deck, an aircraft carrier engaged in flight operations must adjust its speed through the water accordingly. Also, there are other instances such as launch and recovery of a small rigid hull inflatable boat or retrieval of a target when vessels would be dead in the water or moving slowly ahead to maintain steerage. There are a few specific testing and training events that include high-speed requirements for certain systems where vessels would operate at higher speeds.

Table 3.0-10 provides examples of the types of vessels, length, and speeds used in both testing and training activities. The U.S. Navy Fact Files, available on the Internet at http://www.navy.mil/navydata/fact.asp, provide the latest information on the quantity and specifications of the vessels operated by the Navy.

Table 3.0-10: Representative Vessel Types, Lengths, and Speeds

Type	Example(s)	Length	Typical Operating Speed
Aircraft Carrier	Aircraft Carrier (CVN)	>1,000 ft.	10–30 knots
Surface Combatant	Guided Missile Cruisers and Destroyers, Littoral Combat Ships (LCS)	300–700 ft.	10–40 knots
Amphibious Warfare Ship	Amphibious Assault Ship (LHA, LHD), Amphibious Transport Dock (LPD), Dock Landing Ship (LSD)	300–900 ft.	10–15 knots
Support Craft/Other	High-Speed Maneuvering Surface Target (HSMST) or QST-35	15–140 ft.	0–40 knots
Test Ship	Self Defense Test Ship	0-600 ft.	0–15 knots
Other	Coast Guard Cutter (WMSL)	418 ft.	28 knot (max)
Submarines	Fleet Ballistic Missile Submarines (SSBN)	300–600 ft.	8–13 knots

Notes: > indicates greater than, ft. = feet

The number of PMSR-associated Navy vessels in the Study Area at any given time varies and is dependent on scheduled testing and training requirements. Most activities include either one or two vessels and may last from a few hours to two weeks. Vessel movement as part of the Proposed Action would be widely dispersed throughout the PMSR.

In an attempt to determine traffic patterns for Navy and non-Navy vessels, the Center for Naval Analysis (Mintz & Parker, 2006) conducted a review of historic data for commercial vessels, coastal shipping patterns, and all Navy vessels. Commercial and non-Navy traffic, which included cargo vessels, bulk carriers, passenger vessels, and oil tankers (all over 20 m in length), was heaviest along the U.S. West Coast between San Diego and Seattle (Puget Sound) (Mintz & Parker, 2006). Well-defined International shipping lanes within the Study Area are also heavily traveled. Compared to coastal vessel activity, there was relatively little concentration of vessels in the other portions of the Study Area (Mintz & Parker, 2006).

Activities are not always conducted independently of each other, as there are instances where a testing or training activity could occur on a vessel while another testing or training activity is being conducted on the same vessel simultaneously.

Table 3.0-11 shows the number of vessel activity that currently occurs within the PMSR and the number of activities proposed under each alternative. The manner in which the Navy uses vessels to accomplish its testing activities is likely to remain consistent with the range of variability observed over the last decade. Consequently, the Navy is not proposing appreciable changes in the levels, frequency, or locations where vessels have been used over the last decade.

Table 3.0-11: Number of Vessel Activity Within the Point Mugu Sea Range

Activity	Baseline	Alternative 1	Alternative 2
Sea Range Vessel Activity	300	333	333
Support Boat Operations	198	199	199
Total	498	532	532

3.0.5.8.2 Military Expended Materials

Military expended materials that may cause physical disturbance or strike include (1) all sizes of non-explosive practice munitions, (2) fragments from high-explosive munitions, (3) expendable targets, and (4) expended materials other than munitions. The number and type of military material expended in the Study Area is presented in Table 3.0-12.

For living marine resources in the water column, the discussion of military expended material strikes focuses on the potential of a strike at the surface of the water. The effect of materials settling on the bottom will be discussed as an alteration of the bottom substrate and associated organisms (e.g., invertebrates and vegetation).

Natural and cultural resources on SNI may be affected by activity occurring at the Land Impact Site, a target area used for air-to-surface tests employing inert-only weapon systems. The Land Impact Site is the only active impact site on SNI and has been in use since 1989 (U.S. Department of the Navy, 2013). The size and extent of debris from inert missiles, rockets, or bombs, as well as from a target depends upon which target is used (e.g., Container Express [commonly known as CONEX] box, helicopter and/or aircraft bodies, as well as other constructed simulated targets), the size and shape of weapon system, the wind, and incoming weapon trajectory.

Table 3.0-12: Numbers of Military Expended Material in the Point Mugu Sea Range Under the Environmental Baseline, Alternative 1 (Preferred Alternative), and Alternative 2

Military Expended Materials	Environmental Baseline	Alternative 1	Alternative 2
Missiles	231	584	396
Gun Ammunition (small, medium, and large caliber)	11,670	281,230	40,230
Bombs and Rockets	52	70	86
Aerial Targets	104	176	169
Surface Targets	430	522	843
Flares*	28	10	10
Chaff*	20	16	10

*Not counted in the total number of MEM as this item would not contribute to impacts on the seafloor and would break down to fibrous parts that, although ingestible, would not entangle or physically impact resources in the Study Area.

3.0.5.9 Entanglement Stressors

Decelerators/parachutes used during testing and training activities are classified into four different categories based on size: small, medium, large, and extra-large. Aerial targets (drones) use large (between 30 and 50 ft. in diameter) and extra-large (80 ft. in diameter) decelerators/parachutes. Large and extra-large decelerators/parachutes are also made of cloth and nylon, with suspension lines of varying lengths (large: 40–70 ft. in length [with up to 28 lines per decelerator/parachute]; extra-large: 82 ft. in length [with up to 64 lines per decelerator/parachute]). Some aerial targets also use a small drag parachute (6 ft. in diameter) to slow their forward momentum prior to deploying the larger primary decelerator/parachute. Unlike the small- and medium-sized decelerators/parachutes, drone decelerators/parachutes do not have weights attached and may remain at the surface or suspended in the water column for some time prior to eventual settlement on the seafloor.

3.0.5.10 Ingestion Stressors

This section describes the ingestion stressors introduced into the water through naval testing and training, and the relative magnitude and location of these activities in order to provide the basis for analysis of potential impacts on resources in the remainder of this chapter. To assess the ingestion risk of materials expended during testing and training, the Navy examined the characteristics of these items (such as buoyancy and size) for their potential to be ingested by marine animals in the Study Area.

The Navy expends the following types of materials that could become ingestion stressors during testing and training in the Study Area: non-explosive practice munitions (small- and medium-caliber), fragments from high-explosives, fragments from targets, chaff, flare casings (including plastic end caps and pistons), and some decelerators/parachutes. Other military expended materials such as targets, large-caliber projectiles, intact testing bombs, 55-gallon drums, and marine markers are too large for marine organisms to consume and are eliminated from further discussion regarding ingestion.

Solid metal materials, such as small-caliber projectiles or fragments from high-explosive munitions, sink rapidly to the seafloor. Lighter plastic items may be caught in currents and gyres or entangled in floating kelp and could remain in the water column for hours to weeks or indefinitely before sinking (e.g., plastic end caps [from chaff cartridges] or plastic pistons [from flare cartridges]).

3.0.5.10.1 Non-Explosive Practice Munitions

Only small- or medium-caliber projectiles and flechettes (small metal darts) from some non-explosive rockets would be small enough for marine animals to ingest. This would vary depending on the resource and will be discussed in more detail within each resource section. Small- and medium-caliber projectiles include all sizes up to and including those that are 2.25 in. in diameter. Flechettes from some non-explosive rockets are approximately 2 in. in length. Each non-explosive flechette rocket contains approximately 1,180 individual flechettes that are released. These solid metal materials would quickly move through the water column and settle to the seafloor.

3.0.5.10.2 Fragments from High-Explosive Munitions

Many different types of high-explosive munitions can result in fragments that are expended at sea during testing and training activities. Types of high-explosive munitions that can result in fragments include gun ammunition, missiles, rockets, and bombs. Fragments would result from fractures in the munitions casing and would vary in size depending on the size of the net explosive weight and munition type; typical sizes of fragments are unknown. These solid metal materials would quickly sink through the water column and settle to the seafloor.

3.0.5.10.3 Military Expended Materials Other Than Munitions

Several different types of materials other than munitions are expended at sea during testing and training activities.

Target-Related Materials

At-sea targets are usually remotely operated airborne and surface traveling units, many of which are designed to be recovered for reuse. However, if they are used during activities that use high-explosives, they may result in fragments and ultimate loss of the target. Expendable targets that may result in fragments include air-launched decoys and surface targets (e.g., marine markers, cardboard boxes, and 10 ft. diameter red balloons). Most target fragments would sink quickly to the seafloor. Floating material, such as Styrofoam, may be lost from target boats and remain at the surface for some time. Only targets that may result in smaller fragments are included in the analyses of ingestion potential.

There are additional types of targets discussed previously, but only surface targets and air targets would be expected to result in fragments when high-explosive munitions are used.

Chaff

Chaff consists of reflective, aluminum-coated glass fibers used to obscure ships and aircraft from radar-guided systems. Chaff, which is stored in canisters, is either dispensed from aircraft or fired into the air from the decks of surface ships when an attack is imminent. The glass fibers create a radar cloud that mask the position of the ship or aircraft. Chaff is composed of an aluminum alloy coating on glass fibers of silicon dioxide (U.S. Department of the Air Force, 1997). Chaff is released or dispensed in cartridges or projectiles that contain millions of fibers. When deployed, a diffuse cloud of fibers is formed that is undetectable to the human eye. Chaff is a very light material, similar to fine human hair. It can remain suspended in air anywhere from 10 minutes to 10 hours and can travel considerable distances from its release point, depending on prevailing atmospheric conditions (Arfsten et al., 2002); (U.S. Department of the Air Force, 1997). Doppler radar has tracked chaff plumes containing approximately 900 g of chaff drifting 200 mi. from the point of release, with the plume covering greater than 400 mi. (Arfsten et al., 2002).

The number of chaff activities is provided in Table 2-2. The chaff concentrations that marine animals could be exposed to following the release of multiple cartridges (e.g., following a single day of testing or training) is difficult to accurately estimate because it depends on several variable factors. First, specific release points are not recorded and tend to be random, and chaff dispersion in air depends on prevailing atmospheric conditions. After falling from the air, chaff fibers would be expected to float on the sea surface for some period, depending on wave and wind action. The fibers would be dispersed farther by sea currents as they float and slowly sink toward the bottom. Chaff concentrations in benthic habitats following the release of a single cartridge would be lower than the values noted in this section, based on dispersion by currents and the dilution capacity of the ocean.

Several literature reviews and controlled experiments indicate that chaff poses little risk to organisms, except at concentrations substantially higher than those that could reasonably occur from military training (Arfsten et al., 2002); (U.S. Department of the Air Force, 1997); (U.S. Department of the Navy, 1999). Nonetheless, some marine animal species within the Study Area could be exposed to chaff through direct body contact, inhalation, and ingestion. Chemical alteration of water and sediment from decomposing chaff fibers is not expected to occur. Based on the dispersion characteristics of chaff, it is likely that marine animals would occasionally come in direct contact with chaff fibers while either at the water's surface or while submerged, but such contact would be inconsequential. Because of the flexibility and softness of chaff, external contact would not be expected to impact most wildlife (U.S. Department of the Air Force, 1997), and the fibers would quickly wash off shortly after contact. Given the properties of chaff, skin irritation is not expected to be a problem (U.S. Department of the Air Force, 1997). The potential exists for marine animals to inhale chaff fibers if they are at the surface while chaff is airborne. Arfsten et al. (2002), U.S. Department of the Navy (1999), and U.S. Department of the Air Force (1997) reviewed the potential impacts of chaff inhalation on humans, livestock, and other animals and concluded that the fibers are too large to be inhaled into the lungs. The fibers were predicted to be deposited in the nose, mouth, or trachea and either swallowed or expelled.

In laboratory studies conducted by the University of Delaware (U.S. Department of the Navy, 1999), blue crabs and killifish were fed a food-chaff mixture daily for several weeks, and no significant mortality was observed at the highest exposure treatment. Similar results were found when chaff was added directly to exposure chambers containing filter-feeding menhaden. Histological examination indicated no damage from chaff exposures. A study on cow calves that were fed chaff found no evidence of digestive disturbance or other clinical symptoms (U.S. Department of the Air Force, 1997).

Chaff cartridge plastic end caps and pistons would also be released into the marine environment, where they would persist for long periods and could be ingested by marine animals. Chaff end caps and pistons sink in saltwater (Spargo, 2008).

Flares

Flares are pyrotechnic devices used to defend against heat-seeking missiles, where the missile seeks out the heat signature from the flare rather than the aircraft's engines. Similar to chaff, flares are also dispensed from aircraft. The flare device consists of a cylindrical cartridge approximately 1.4 in. in diameter and 5.8 in. in length. Flares are designed to burn completely. The only material that would enter the water would be a small, round, plastic compression pad or piston (0.45–4.1 grams depending on flare type). The flare pads and pistons float in sea water. The number of flare activities is provided in Table 2-2.

An extensive literature review and controlled experiments conducted by the U.S. Air Force revealed that self-protection flare use poses little risk to the environment or animals (U.S. Department of the Air Force, 1997).

3.0.5.11 Representative Activities and Associated Stressors

Table 3.0-13 describes activities by event type and a list of potential stressors that may result from each activity.

Table 3.0-13: Representative Activities and Associated Stressors

Activity	Aircraft	Vessel	Target Type	Ordnance	Stressor	Resources Affected
Air-to-Air	F/A-18 F-35 F-22 F-15 F-16 E-2 P-3/NC-37 KC-130 Foreign	N/A	BQM-34 BQM-177 ITALD QF-16	AIM-9 AIM-120 20mm Gun 25mm Gun Foreign	✓Acoustic – aircraft and weapons noise ✓Physical Disturbance/Strike ✓Entanglement ✓Ingestion	✓3.3 Marine Habitats ✓3.4 Marine Vegetation ✓3.5 Marine Invertebrates ✓3.6 Marine Fishes ✓3.7 Marine Mammals ✓3.8 Sea Turtles ✓3.9 Marine Birds ✓3.10 Cultural Resources
Air-to-Surface	F/A-18 F-35 F-22 F-15 F-16 E-2 P-8 B-1 B-2 B-21 B-52 MQ-8C MH-60 P-3/NC-37 KC-130 CAS	ATLS-9701 Contract Vessel Diane G SL-120	SDTS HSMST FAC MST QST-35 LCMT	GBU (250/500) LRASM AGM-84 AGM-114 AGM-179 (JAGM) .50 cal 7.62 mm APKWS HSSW	✓Acoustic – aircraft, vessel, and weapons noise ✓Surface Explosives ✓Physical Disturbance/Strike ✓Ingestion	✓3.3 Marine Habitats ✓3.4 Marine Vegetation ✓3.5 Marine Invertebrates ✓3.6 Marine Fishes ✓3.7 Marine Mammals ✓3.8 Sea Turtles ✓3.9 Marine Birds ✓3.10 Cultural Resources

Table 3.0-13: Representative Activities and Associated Stressors (continued)

Activity	Aircraft	Vessel	Target Type	Ordnance	Stressor	Resources Affected
Surface-to-Air	F-16 FA-18 P-3/NC-37 C-130 CAS	DDG CG CVN LHA LHD LPD LSD LCS Foreign	BQM-34 BQM-177 ITALD QF-16 AQM-37 GQM-163A	RIM-162D (ESSM) SM-2 SM-3 SM-6 RIM-116 (RAM) SeaRAM 20mm CWIS Foreign	✓Acoustic – aircraft, vessel, and weapons noise ✓In-Air Explosives ✓Energy (in-air only) ✓Physical Disturbance/Strike ✓Entanglement ✓Ingestion	✓3.3 Marine Habitats ✓3.4 Marine Vegetation ✓3.5 Marine Invertebrates ✓3.6 Marine Fishes ✓3.7 Marine Mammals ✓3.8 Sea Turtles ✓3.9 Marine Birds ✓3.10 Cultural Resources
Surface-to-Surface	P-3/NC-37 C-130 CAS	DDG CG LCS Foreign	SDTS HSMST FAC MST QST-35 LCMT	LRASM RIM-162D (ESSM) SM-2 SM-3 SM-6 RIM-116 (RAM) 20mm CIWS NSM 5”/54/62 cal 57mm .50 cal DDG-1000 future gun Foreign	✓Acoustic – aircraft, vessel, and weapons noise ✓Surface Explosives ✓Physical Disturbance/Strike ✓Ingestion	✓3.3 Marine Habitats ✓3.4 Marine Vegetation ✓3.5 Marine Invertebrates ✓3.6 Marine Fishes ✓3.7 Marine Mammals ✓3.8 Sea Turtles ✓3.9 Marine Birds ✓3.10 Cultural Resources
Subsurface-to-Surface	P-3/NC-37 C-130 CAS	SSN	SDTS MST	LRASM UGM-84	✓Acoustic – aircraft, vessel, and weapons noise ✓Surface Explosives ✓Physical Disturbance/Strike ✓Ingestion	✓3.3 Marine Habitats ✓3.4 Marine Vegetation ✓3.5 Marine Invertebrates ✓3.6 Marine Fishes ✓3.7 Marine Mammals ✓3.8 Sea Turtles ✓3.9 Marine Birds

Table 3.0-13: Representative Activities and Associated Stressors (continued)

Activity	Aircraft	Vessel	Target Type	Ordnance	Stressor	Resources Affected
Electronic Warfare	FA-18 F-35 P-8 UAS Foreign	DDG CG CVN LHA LHD LPD LSD LCS Foreign	SNI, Point Mugu, and other targets (surface targets on the sea range)	TALD AGM-88 Advanced Anti-Radiation Guided Missile (AARGM) Advanced Strike Weapon (ASW) Chaff Flares	✓Acoustic – aircraft and vessel noise ✓Energy (in-air only) ✓Physical Disturbance/Strike ✓Ingestion	✓3.6 Marine Fishes ✓3.7 Marine Mammals ✓3.8 Sea Turtles ✓3.9 Marine Birds ✓3.10 Cultural Resources
Directed Energy Weapons	P-3/NC-37	DDG LPD	SDTS HSMST FAC MST QST-35 LCMT UAS BQM-34 BQM-177 AQM-37 GQM-163A SNI Land Targets	HPM HEL	✓Acoustic – aircraft and vessel noise ✓Energy (HEL and microwave) ✓Physical Disturbance/Strike ✓Entanglement ✓Ingestion	✓3.6 Marine Fishes ✓3.7 Marine Mammals ✓3.8 Sea Turtles ✓3.9 Marine Birds

Target Types: AQM = Air-launched Supersonic Target Drone, BQM = Recoverable Target Drone, FAC = Fast Attack Craft, GQM = Ground Launched Supersonic Target Drone, HSMST = High Speed Maneuverable Surface Target, ITALD = Improved Tactical Air Launched Decoy, LCMT = Low Cost Modular Target, MST = Mobile Ship Target, QF-16 = Remote Controlled F-16 Target, QST-35 = Remote Controlled Surface Target, SDTS = Self-Defense Test Ship, TALD = Tactical Air Launched Decoy, UAS = Unmanned Aircraft System

Ordnance Types: AARGM = Advanced Anti-Radiation Guided Missile, ASW = Advanced Strike Weapon, AGM = Air-to-Ground Missile, AGM-(JAGM) = Joint Air-to-Ground Missile, AIM = Air-to-Air Missile, APKWS = Advanced Precision Kill Weapon System, CIWS = Close In Weapons System, GBU = Guided Bomb Unit, HEL = High Energy Laser, HPM = High Powered Microwave, HSSW = High Speed Strike Weapon, LRASM = Long Range Anti-ship Missile, NSM = Naval Strike Missile, RIM-116 (RAM) = Rolling Airframe Missile, RIM-162D (ESSM) = Evolved Sea Sparrow Missile, RIM = Radar Intercept Missile, SeaRAM = Combined key attributes of the CIWS and RAM, SM = Standard Missile, UGM = Underwater-launched Surface Attack Missile.

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