Environmental Impact Statement/

Overseas Environmental Impact Statement

Point Mugu Sea Range

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3.6 Marine Fishes

3.6.1 Introduction

This section analyzes the potential impacts of the Proposed Action on fishes found in the Point Mugu Sea Range (PMSR) Study Area. Section 3.6.4.2 (Marine Fishes in the Study Area) introduces the species that occur in the Study Area and discusses the taxonomic groupings; the analysis of environmental consequences is in Section 3.6.5 (Environmental Consequences).

For this Environmental Impact Statement/Overseas Environmental Impact Statement, marine fishes are evaluated as groups of species characterized by distribution, morphology (body type), or behavior relevant to the stressor being evaluated. Activities are evaluated for their potential effects on the marine fish in the Study Area. Fishes are not distributed uniformly throughout the Study Area but are closely associated with a variety of habitats. Some species, such as large sharks, salmon, tuna, and billfishes, range across thousands of square miles. Other species, such as gobies and most fishes associated with rocky reefs, generally have small home ranges and restricted distributions (Helfman et al., 2009). The early life stages (e.g., eggs and larvae) of many fish may be widely distributed even when the adults have relatively small ranges. The movements of some open-ocean species may never overlap with coastal fishes that spend their lives within several hundred feet of the shore. The distribution and specific habitats in which an individual of a single fish species occurs may be influenced by its life stage, size, sex, reproductive condition, and other factors. Approximately 78 percent of all marine fish species occur in waters less than 200 meters (m) deep and in close association with land, while 13 percent are associated with the open ocean (Moyle & Cech, 2004).

3.6.2 Region of Influence

The region of influence for marine fishes consists of the PMSR and the offshore areas surrounding Point Mugu and San Nicolas Island (SNI). While Navy support boats and surface targets transit in and out of Port Hueneme to the PMSR, marine fishes within the port are not addressed further because vessel transits would not affect marine fishes within Port Hueneme.

3.6.3 Approach to Analysis

The following factors were used to determine potential impacts on marine fishes from the Proposed Action. The determination of significance is based on the review of the literature presented in this section and from the most recent Navy documents that analyzed potential impacts from the same or similar activities on marine fishes (U.S. Department of the Navy, 2018a, 2018b).

Potential impacts on marine fishes would come primarily from direct physical injury and detrimental behavioral effects due to exposure to noise (from aircraft, vessels, and weapons firing) or shock waves from explosions at the surface of the water, as well as the risk of physical disturbance and strike or ingestion of military expended materials. Analysis of these stressors on marine fishes is presented in Section 3.6.5 (Environmental Consequences), as well as mitigation measures that would be implemented by the Navy to avoid or reduce impacts on marine fishes.

3.6.4 Affected Environment

Two subsections are included in this section. General background information is given in Section 3.6.4.1 (General Background), which provides brief summaries of habitat use, movement and behavior, and threats that affect or have the potential to affect fishes within the Study Area.

3.6.4.1 General Background

Fishes are the most numerous and diverse of the major vertebrate groups (Moyle & Cech, 2004). It is estimated that there are currently over 34,000 species of fishes worldwide (Eschmeyer & Fong, 2017), with greater than half that number of species inhabiting the oceans.

Marine fishes can be broadly categorized by their distributions within the water column or habitat usage. Moyle and Cech (2004) define the major marine habitat categories as estuaries, coastal habitats, reefs, the epipelagic zone, the deep sea, and the Polar regions. In the Study Area, the major habitat categories include all of the aforementioned except the Polar regions. Many marine fishes that occur in the Study Area are either demersal species (i.e., close to the seafloor) associated with nearshore coastal habitats, or are more oceanic and live in surface waters (pelagic) further offshore (Schwartz, 1989). The highest number and diversity of fishes typically occur where the habitat has structural complexity (e.g., hard bottom systems, continental slopes, deep canyons), biological productivity (areas of nutrient upwelling), and a variety of physical and chemical conditions (e.g., water flow, nutrients, dissolved oxygen, and temperature) (Bergstad et al., 2008; Helfman et al., 2009; Moyle & Cech, 2004; Parin, 1984). Some of the marine fishes that occur in the coastal zone migrate between marine and freshwater habitats (Helfman et al., 2009). Other distribution factors, including predator/prey relationships, water quality, and refuge (e.g., physical structure or vegetation cover), operate on more regional or local spatial scales (Reshetiloff, 2004). Also, fishes may move among habitats throughout their lives based on changing needs during different life stages (Schwartz, 1989).

Each major habitat type in the Study Area (e.g., hard bottom, soft bottom, and beds of submerged aquatic vegetation) supports an associated fish community with the number of species increasing with decreasing latitude (transition from north to south). However, this pattern is not as clearly defined for wide-ranging migratory open-ocean species (Macpherson, 2002). The specific characteristics of the wide diversity of habitat and biotic species that make up these habitat types within the Study Area are discussed in Section 3.3 (Marine Habitats), Section 3.4 (Marine Vegetation), and Section 3.5 (Marine Invertebrates).

Some fish species in the United States are protected under the Endangered Species Act (ESA) and are managed by either the United States (U.S.) Fish and Wildlife Service or National Marine Fisheries Service (NMFS). The recreational and commercial fisheries are managed within a framework of overlapping international, federal, state, interstate, and tribal authorities. Individual states and territories generally have jurisdiction over managed fisheries located in marine waters within 3 nautical miles (NM) of their coast. Federal jurisdiction includes managed fisheries in marine waters inside the U.S. Exclusive Economic Zone. The area stretches from the outer boundary of state waters out to 200 NM offshore of any U.S. coastline, except where intersected closer than 200 NM by bordering countries.

The Magnuson-Stevens Fishery Conservation and Management Act and Sustainable Fisheries Act led to the formation of eight regional fishery management councils that coordinate with NMFS to manage and conserve certain fisheries in federal waters. Together with NMFS, the councils maintain fishery management plans for species or species groups comprised of fish, invertebrates, and vegetation to regulate commercial and recreational harvest within their geographic regions. The Study Area overlaps with the jurisdiction of one regional fishery management council, as well as the range of the highly migratory species (e.g., sharks, billfishes, swordfish, and tunas), which are managed directly by NMFS.

- **The Pacific Fishery Management Council** manages fisheries in the exclusive economic zone off Washington, Oregon, and California.

- **NMFS, Office of Sustainable Fisheries** includes all federally managed waters of the United States where highly migratory species occur.

3.6.4.1.1 Habitat Use

Fishes inhabit most of the world's oceans, from warm shallow coastal habitat to cold deep-sea waters, and are found on the surface, in the water column, and at the bottom in the Study Area. Fish distribution is restricted by biotic factors (competition or predation) or by abiotic components, such as temperature, salinity, dissolved oxygen, and pH. A species can be excluded from a suitable habitat by competitors, predators, parasites, or a lack of available prey (Moyle & Cech, 2004). The description of habitat use in this section pertains to common fishes found in the different habitats. The abiotic (non-living) components of all habitat types are addressed in Section 3.3 (Marine Habitats), marine invertebrates are covered in Section 3.5, sediment and water quality conditions are addressed in Section 3.2, and marine vegetation is discussed in Section 3.4.

Estuaries are comprised of brackish water, where freshwater mixes with saltwater to form transitional environments between rivers and the ocean. The fluctuating nature of the estuarine environment means that the fishes inhabiting or transiting through expend considerable amounts of energy adjusting to the changing conditions. Fishes found in estuaries are of five broad types: (1) freshwater (e.g., nonnative catfishes [*Ictalurus* species]), (2) diadromous species that spend part of their lives in freshwater and part of their lives in saltwater (e.g., sturgeon and salmon), (3) true estuarine (e.g., Delta smelt [*Hypomesus transpacificus*]), (4) marine species that use estuaries but do not necessarily need them (e.g., starry flounder (*Platichthyes stellatus*]), and (5) marine species that need estuaries for at least one stage of their lives (e.g., herrings [*Clupea* species]) (Moyle & Cech, 2004). Estuaries are primarily composed of soft bottom (e.g., sand and sandy sediments and mudflats), and many contain a variety of benthic habitat types such as seagrass beds and hard substrate such as oyster reefs.

Marine and diadromous fishes inhabit the diverse coastal habitats on or near the edges of the continents, from the intertidal regions to the edge of the continental shelf (Moyle & Cech, 2004). The most abundant and conspicuous types of coastal habitats are hard bottom (e.g., rocky reefs, which can include shell beds), soft bottom (e.g., sand, mud, silt), submerged aquatic vegetation (e.g., mangroves, salt marshes, seagrass beds, macroalgae beds), and floating macroalgae. Each of these coastal habitats has distinct types of fishes associated with it. Common fishes inhabiting hard bottom habitats in the Study Area include gobies (Gobiidae), rockfishes (Scorpaenidae), and sculpins (Cottidae), while flatfishes (Bothidae) and rays (Dasyatidae) are found on soft bottoms. Pipefishes (Syngnathidae) and kelpfish (Clinidae) are common inhabitants of submerged aquatic vegetation habitat. Species commonly found under offshore floating macroalgae include molas (Molidae), tunas (Scombridae), and various sharks (Lamnidae and Carcharhinidae).

The upper 200 m of the ocean is known as the photic or epipelagic zone. Nearshore epipelagic fishes are overall the most commercially valuable group of fishes to humans because they typically occur in large schools, such as herring (Clupeidae) and anchovies (Engraulidae), or are particularly favored as food, such as tunas (Scombridae) and salmon (Salmonidae). Predators on nearshore epipelagic fishes include billfishes and swordfishes (Xiphiidae), sharks (Carcharhinidae), and others. Epipelagic fishes that inhabit the open ocean spend their entire life cycle either free swimming or associated with drifting seaweed (e.g., kelp) (Moyle & Cech, 2004). In the Study Area, examples of epipelagic open ocean fishes include sharks, tunas, sauries (Scomberesocidae), and ocean sunfish.

Mesopelagic habitats are found below the well-lighted, well-mixed epipelagic zone. Lanternfishes (Myctophidae), with about 240 species, are an important group of mesopelagic deep sea fishes in terms of diversity, distribution, and numbers of individuals (Helfman et al., 2009). These species make up a large fraction of the deep scattering layer, so-called because the sonic pulses of a sonar can reflect off the millions of swim bladders, often giving the impression of a false bottom (Moyle & Cech, 2004). Generally, deep sea fishes are divided into two groups, those that are found in the water column and others associated with the seafloor. In the Study Area, the cookie cutter shark (Dalatiidae), fangtooths (Anoplogastridae), hatchetfishes (Sternoptychidae), and lanternfishes (Myctophidae) inhabit the water column, while the seafloor is inhabited with grenadiers or rattails (Macrouridae), hagfishes (Myxinidae), rays (Rajidae), and some rockfishes (Sebastidae).

Some fishes use one habitat type over their entire life cycle, while others associate with different habitat types by life stage. Anadromous fishes such as the steelhead (*Oncorhynchus mykiss*) hatch and rear in freshwater rivers as larvae. Early juveniles inhabit estuaries as they transition into late-juvenile and early sub-adult life stages before entering the ocean to mature into adults. Many other marine fishes inhabit the water column as larvae, settling onto soft bottom habitat as juveniles and remaining there as adults (e.g., flatfishes). The oceanic Pacific bluefin tuna (*Thunnus orientalis*) provides an example of a species closely connected to one habitat category across their life cycle.

3.6.4.1.2 Movement and Behavior

Fishes exhibit a rich array of sophisticated behavior (Meyer et al., 2010). Fishes have been shown to cooperate in a variety of ways during foraging, navigation, reproduction, and predator avoidance (Fitzpatrick et al., 2006; Huntingford et al., 2006; Johnstone & Bshary, 2004). Some examples of the common types of behavior exhibited by fishes include movement or migration, schooling, feeding, and resting (Moyle & Cech, 2004).

Migratory behavior consists of mass movements from one place to another and can range in occurrence from daily to seasonal, depending on the species. Tunas, salmon, and eels migrate thousands of miles in short periods of time (e.g., a few months). Daily or seasonal migrations are typically for feeding or predator avoidance and can also be referred to as movement patterns. Some common movement patterns include coastal migrations, open ocean migrations, onshore/offshore movements, vertical water column movements, and life stage-related migrations (e.g., eggs and larvae as part of the plankton/nekton). Many fishes have the ability to find their way back to a "home" area, and some species use olfactory and visual cues, as well as chemicals released by the other fishes to return home. Highly migratory species such as hammerhead shark (*Sphyrna* species), basking shark (*Cetorhinus maximus*), and swordfish (*Xiphias gladius*), may move across thousands of miles of open ocean. Other migratory species such as the steelhead exhibit seasonal movement patterns throughout coastal continental shelf waters and beyond.

A shoal is defined as any group of fishes that remain together for social reasons, while a school is a polarized, synchronized shoal (Moyle & Cech, 2004), often swimming together in tight formations. Schools can change shape when traveling, feeding, resting, or avoiding predators. Vision and the lateral-line system (defined in Section 3.6.4.1.3, Hearing and Vocalization) play roles in assisting schooling by allowing fish to visually orientate to one another and also sense water movements when visibility is reduced. Schooling behavior may provide protection against predators. Schooling may also be beneficial in terms of reproduction since little energy has to be expended to find a mate when sexes school together (Moyle & Cech, 2004).

3.6.4.1.3 Hearing and Vocalization

All fishes have two sensory systems that can detect sound in the water: the inner ear, which functions similarly to the inner ear in other vertebrates, and the lateral line, which consists of a series of receptors along the body of a fish (Popper & Schilt, 2008). The lateral line system is sensitive to external particle motion arising from sources within a few body lengths of the animal. The lateral line detects particle motion at low frequencies from below 1 hertz (Hz) up to at least 400 Hz (Coombs & Montgomery, 1999; Hastings & Popper, 2005; Higgs & Radford, 2013; Webb et al., 2008). Generally, the inner ears of fish contain three dense otoliths (i.e., small calcareous bodies) that sit atop many delicate mechanoelectric hair cells within the inner ear of fishes, similar to the hair cells found in the mammalian ear. Sound waves in water tend to pass through the fish's body, which has a composition similar to water, and vibrate the otoliths. This causes a relative motion between the dense otoliths and the surrounding tissues, causing a deflection of the hair cells, which is sensed by the nervous system.

Historically, studies that have investigated hearing in, and effects on, fishes have been carried out with sound pressure metrics. Although particle motion may be the more relevant exposure metric for many fish species, there is little data available that actually measures it due to a lack of standard measurement methodology and experience with particle motion detectors (Hawkins et al., 2015; Martin et al., 2016). In these instances, particle motion can be estimated from pressure measurements (Nedelec et al., 2016).

Some fishes possess additional morphological adaptations or specializations that can enhance their sensitivity to sound pressure, such as a gas-filled swim bladder (Astrup, 1999; Popper & Fay, 2010; Popper & Hastings, 2009b). The swim bladder can enhance sound detection by converting acoustic pressure into localized particle motion, which may then be detected by the inner ear (Radford et al., 2012). Fishes with a swim bladder generally have better sensitivity and can detect higher frequencies than fishes without a swim bladder (Popper & Fay, 2010; Popper et al., 2014). In addition, structures such as gas-filled bubbles near the ear or swim bladder, or even connections between the swim bladder and the inner ear, also increase sensitivity and allow for high-frequency hearing capabilities and better sound pressure detection.

Although many researchers have investigated hearing and vocalizations in fish species (Ladich & Fay, 2013; Popper et al., 2014), hearing capability data only exist for just over 100 of the currently known 34,000 marine and freshwater fish species (Eschmeyer & Fong, 2016). Therefore, fish hearing groups are defined by species that possess a similar continuum of anatomical features, which result in varying degrees of hearing sensitivity (Popper & Fay, 2010; Popper & Hastings, 2009b). The following categories and descriptions of hearing sensitivities are further defined in this document (modified from Popper et al., 2014):

- Fishes without a swim bladder (e.g., sharks and rays)—hearing capabilities are limited to particle motion detection at frequencies well below 1 kilohertz (kHz).
- Fishes with a swim bladder not involved in hearing (e.g., rockfishes)—species lack notable anatomical specializations and primarily detect particle motion at frequencies below 1 kHz.
- Fishes with a swim bladder involved in hearing (e.g., anchovy and sardines)—species can detect frequencies below 1 kHz, possess anatomical specializations to enhance hearing, and are capable of sound pressure detection up to a few kHz.

Data suggest that most species of marine fishes either lack a swim bladder (e.g., sharks and flatfishes) or have a swim bladder not involved in hearing and can only detect sounds below 1 kHz. Some marine fishes (clupeiforms) with a swim bladder involved in hearing are able to detect sounds to about 4 kHz (Colleye et al., 2016; Mann et al., 2001; Mann et al., 1997). One subfamily of clupeids (i.e., Alosinae) can detect high- and very high-frequency sounds (i.e., frequencies from 10 to 100 kHz, and frequencies above 100 kHz, respectively), although auditory thresholds at these higher frequencies are elevated and the range of best hearing is still in the low-frequency range (below 1 kHz) similar to other fishes. Mann et al. (1998; 1997) theorize that this subfamily may have evolved the ability to hear relatively high sound levels at these higher frequencies in order to detect echolocations of nearby foraging dolphins. For fishes that have not had their hearing tested, such as deep sea fishes, the suspected hearing capabilities are based on the structure of the ear, the relationship between the ear and the swim bladder, and other potential adaptations such as the presence of highly developed areas of the brain related to inner ear and lateral line functions (Buran et al., 2005; Deng et al., 2011, 2013). It is believed that most fishes have their best hearing sensitivity from 100 to 400 Hz (Popper, 2003).

As discussed above, most marine fishes investigated to date lack hearing capabilities greater than 1 kHz. This notably includes steelhead (Song et al., 2006), a species with a swim bladder that is not involved in hearing. Steelhead hearing has only been tested up to 500 Hz (Ladich & Fay, 2013), but they likely possess similar hearing ranges to other salmonids (i.e., up to 1 kHz) due to similarities between the inner ear structures and swim bladder morphology. Rays and sharks are cartilaginous fishes (i.e., elasmobranchs) lacking a swim bladder. Available data suggest these species can detect sounds from 20 to 1,000 Hz, with best sensitivity at lower ranges (Casper et al., 2003; Casper & Mann, 2006; Casper & Mann, 2009; Myrberg, 2001).

Some fishes are known to produce sound. Bony fishes can produce sounds in a number of ways and use them for a number of behavioral functions (Ladich, 2008, 2014). Over 30 families of fishes are known to use vocalizations in aggressive interactions, and over 20 families are known to use vocalizations in mating (Ladich, 2008). Sounds generated by fishes as a means of communication are generally below 500 Hz (Slabbekoorn et al., 2010). The air in the swim bladder is vibrated by the sound-producing structures (often muscles that are integral to the swim bladder wall) and radiates sound into the water (Zelick et al., 1999). Sprague and Luczkovich (2004) calculated that silver perch, of the family sciaenidae, can produce drumming sounds ranging from 128 to 135 decibels (dB) referenced to 1 micropascal. Female midshipman fish apparently detect and locate the “hums” (approximately 90 to 400 Hz) of vocalizing males during the breeding season (McIver et al., 2014; Sisneros & Bass, 2003). Sciaenids produce a variety of sounds, including calls produced by males on breeding grounds (Ramcharitar et al., 2001) and a “drumming” call produced during chorusing that suggests a seasonal pattern to reproductive-related function (McCauley & Cato, 2000).

3.6.4.1.4 General Threats

Fish populations can be influenced by various natural factors and human activities. There can be direct effects, from disease or from commercial and recreational activities such as fishing, or indirect effects, such as those associated with reductions in prey availability or lowered reproductive success of individuals. Human-made impacts are widespread throughout the world’s oceans, such that very few habitats remain unaffected by human influence (Halpern et al., 2008a). Direct and indirect effects have shaped the condition of marine fish populations, particularly those species with large body size, late maturity ages, or low fecundity, such as sharks, Pacific cod (*Gadus macrocephalus*), and Pacific bluefin (*Thunnus thynnus*) tuna, making these species especially vulnerable to habitat losses and fishing pressure (Reynolds et al., 2005). Human-induced stressors (e.g., threats) can be divided into four components, which often act on fish populations simultaneously: habitat alteration, exploitation, introduction of non-native species, and pollution (Moyle & Cech, 2004). Climate change and its resulting effects on the marine environment are additional stressors on fish populations.

Coastal development, deforestation, road construction, dam development, water control structures, and agricultural activities are types of habitat alteration that can affect fishes and their environment. These activities may affect the water quality of the nearshore marine environment. Threats to fishes related to poor water quality are discussed in Section 3.6.4.1.4.1 (Water Quality). Threats from exploitation, including commercial and recreational fishing industries and other stressors, are addressed in Section 3.6.4.1.4.2 (Commercial and Recreational Activities). Fishes living in suboptimal conditions from habitat alteration and overexploitation due to fishing may be at increased risk of contracting diseases and acquiring parasites, which are covered in Section 3.6.4.1.4.3 (Disease and Parasites). The presence of an introduced species represents a major change in the native fish community, and this topic is discussed in Section 3.6.4.1.4.4 (Invasive Species). The threats to fish from oil spills and pollution are covered in Section 3.6.4.1.4.1 (Water Quality). Climate change and its effects on fishes are addressed in Section 3.6.4.1.4.5 (Climate Change), and effects from marine debris are addressed in Section 3.6.4.1.4.6 (Marine Debris).

3.6.4.1.4.1 Water Quality

Parameters such as temperature, dissolved oxygen, salinity, turbidity, and pH define the water quality as a component of habitat quality for fishes. Some land-based activities can directly and indirectly impact water quality in rivers, estuaries, and coastal waters. Sediment from activities on land may be transported to the marine environment. Sediment can impact water quality conditions for fishes by increasing turbidity and decreasing light penetration into the water column, as well as by transporting contaminants into the marine environment (Allen, 2006). Increases in sediment can decrease the survival and reproduction of plankton and have food web and ecosystem-level effects.

Hypoxia (low dissolved oxygen concentration) is a major impact associated with poor water quality. Hypoxia occurs when waters become overloaded with nutrients such as nitrogen and phosphorus, which enter oceans from agricultural runoff, sewage treatment plants, bilge water, and atmospheric deposition. An overabundance of nutrients can stimulate algal blooms, resulting in a rapid expansion of microscopic algae (phytoplankton), and can cause anoxic events leading to fish kills (Corcoran et al., 2013). Over the last several decades, coastal regions throughout the world have experienced an increase in the frequency of algal blooms that are toxic or otherwise harmful. Commonly called red tides, these events are now grouped under the descriptor harmful algal blooms (Anderson et al., 2002). Harmful algal blooms can produce toxins, causing human illness and massive fish and other animal mortalities (see Section 3.4.4.1.2.3, Disease and Parasites).

Pollution

Chemicals and debris are the two most common types of pollutants in the marine environment. Information on marine debris is provided below in Section 3.6.4.1.4.6 (Marine Debris). Global oceanic circulation patterns result in the accumulation of a considerable amount of pollutants and debris scattered throughout the open ocean and concentrated in gyres and other places (Crain et al., 2009). Pollution initially impacts fishes that occur near the sources of pollution but may also affect future generations from effects on reproduction and increased mortality across life stages.

Chemical pollutants in the marine environment that may impact marine fishes include organic pollutants (e.g., pesticides, herbicides, polycyclic aromatic hydrocarbons, flame retardants, and oil) and inorganic pollutants (e.g., heavy metals) (Pew Oceans Commission, 2003). High chemical pollutant levels in marine fishes may cause behavioral changes, physiological changes, or genetic damage (Goncalves et al., 2008; Moore, 2008; Pew Oceans Commission, 2003). Bioaccumulation is the net buildup of substances (e.g., chemicals or metals) in an organism from inhabiting a contaminated habitat or from ingesting food or prey containing the contaminated substance (Newman, 1998), or from ingesting the substance directly (Moore, 2008). Bioaccumulation of pollutants (e.g., metals and organic pollutants) is also a concern to human health because people consume top predators with high pollutant loads.

Oil Spills

Groups of fish typically impacted by oil spills include surface-oriented or surface-dwelling species, nearshore (within 3 NM of the shoreline) species, and species whose spawning time coincided with an oil spill (Yender et al., 2010). Fishes can be impacted by the oil directly through the gills, or by consuming oil or oiled prey. Potentially harmful physiological effects on fishes from oil spills include reduced growth, enlarged livers, changes to heart and respiration rate, fin erosion, and reproductive impairment. The most damaging effects of oil on fish populations may be in harming eggs and larvae, because these stages are highly sensitive to oil at the surface, in the water column, or on the seafloor, and are subject to increased mortality and morphological deformities and impaired growth (Greer et al., 2012; Ingvarsdottir et al., 2012; National Oceanic and Atmospheric Administration, 2014; Ocean Conservancy, 2010a; Restore the Gulf, 2010). Discharges from ballast water and bilge water during routine ship operations and illegal dumping of solid waste are other sources of oil in the marine environment.

3.6.4.1.4.2 Commercial and Recreational Activities

Exploitation by commercial and recreational fishing is the single biggest cause of changes in fish populations and communities (Moyle & Cech, 2004). Historic and current overfishing largely contributed to the listing of ESA-protected marine species (Crain et al., 2009; Kappel, 2005). Overfishing of a resource results from both legal and illegal fishing (poaching) and bycatch of resources in quantities above a sustainable level. At the end of 2017, 30 managed fish stocks in the United States were on the overfishing list and 35 stocks were on the overfished list, while the number of rebuilt fish stocks since 2000 increased to 44 (National Marine Fisheries Service, 2016b, 2018).

In recent decades, commercial fisheries have targeted the larger, predatory, and sometimes higher-priced fish species. Gradually, this fishing pressure could make the larger species more scarce, and fishing will move towards the smaller species (Pauly & Palomares, 2005). Other factors, such as fisheries-induced evolution and intrinsic vulnerability to overfishing, have been shown to reduce the abundance of some populations (Kauparinen & Merila, 2007). Fisheries-induced evolution is a change in genetic composition of the population that results from intense fishing pressure, such as a reduction in the overall size and growth rates of fishes in a population. Intrinsic vulnerability is when certain life history traits (e.g., large body size, late maturity age, low growth rate, low offspring production) result in a species being more susceptible to overfishing than others (Cheung et al., 2007).

Other threats from commercial industries to fishes include vessel strikes, sea farming, and energy production activities. Large commercial passenger vessels (e.g., cruise liners) pose threats to large, slow-moving open ocean fishes while moving along the sea surface. Within the Study Area, basking sharks (*Cetorhinus maximus*) and ocean sunfish (*Mola mola*) may be vulnerable to ship strikes (National Marine Fisheries Service, 2010a; Rowat et al., 2007; Stevens, 2007).

The threats of aquaculture operations on wild fish populations include reduced water quality, competition for food, predation by escaped or released farmed fishes, spread of disease and parasites, and reduced genetic diversity (Kappel, 2005). These threats become apparent when farmed fish escape and enter the natural ecosystem (Hansen & Windsor, 2006; Ormerod, 2003). The National Oceanic and Atmospheric Administration (2011) published the Marine Aquaculture Policy, which provides direction to enable the development of sustainable marine aquaculture.

Energy production and offshore activities associated with power-generating facilities results in direct and indirect injury or mortality of fishes. Injury and mortality sources include entrainment of eggs and larvae during water withdrawal and impingement of juveniles and adults (U.S. Environmental Protection Agency, 2004). Acoustic impacts from offshore wind energy development are additional sources of injury and mortality (Madsen et al., 2006).

Anthropogenic Noise

Anthropogenic noise is generated from a variety of sources, including commercial shipping; oil and gas exploration and production activities; commercial and recreational fishing (including fish-finding sonar, fathometers, and acoustic deterrent devices); recreational boating; whale watching activities and other marine transportation vessels such as ferries; marine and coastal development (e.g., construction of bridges, ferry terminals, windfarms); and research (including sound from air guns, sonar, and telemetry). Vessel noise in particular is a major contributor to noise in the ocean and is intensively produced in inland waters. Commercial shipping's contribution to ambient noise in the ocean increased by as much as 12 dB between approximately the 1960s and 2005 (Hildebrand, 2009; McDonald et al., 2008). Frisk (2012) confirmed the trend and reported that between 1950 and 2007 ocean noise in the 25–50 Hz frequency range increased 3.3 dB per decade, resulting in a cumulative increase of approximately 19 dB over a baseline of 52 dB (decibels referenced to 1 micropascal squared/Hz). The increase in noise is associated with an increase in commercial shipping, which correlates with global economic growth (Frisk, 2012). Miksis-Olds and Nichols (2016) found low-frequency ocean sound levels have decreased in the South Atlantic and Equatorial Pacific Oceans, similar to a trend of slightly decreasing low-frequency noise levels in the Northeast Pacific. In addition to vessels, other sources of underwater noise include pile-driving activity (Carlson et al., 2007; Casper et al., 2013a; Casper et al., 2012; Casper et al., 2013b; Dahl et al., 2015; Debusschere et al., 2014; Feist et al., 1992; Halvorsen et al., 2012; Popper et al., 2006; Ruggerone et al., 2008; Stadler & Woodbury, 2009), sonar (California Department of Transportation, 2001; Carlson et al., 2007; Mueller-Blenkle et al., 2010; Popper et al., 2006), seismic activity (Popper & Hastings, 2009a), and offshore construction projects (Foderaro, 2015).

Noise can cause permanent injury in some freshwater fishes (Popper et al., 2005). Physiological responses to noise have shown a variety of results for marine fishes. For example, the giant kelpfish (*Heterostichus rostratus*) exhibited acute stress response when exposed to intermittent recorded boat engine noise (Nichols et al., 2015).

3.6.4.1.4.3 Disease and Parasites

Fishes in poor quality environments have higher incidences of disease, due to increased stress levels and decreased immune system function, and are less resilient to fight the disease. Parasites, bacteria, aquaculture conditions, environmental influences, and poor nourishment contribute to fish disease levels (National Oceanic and Atmospheric Administration, 2016a). Disease outbreaks in fishes are influenced by environmental conditions, which typically are more variable in inland waters compared to the open ocean (Snieszko, 1978). Areas with higher density fish populations, such as marine protected areas and fish farms, are at higher risk for disease compared to areas with lower densities (National Oceanic and Atmospheric Administration, 2016b; Wootton et al., 2012). Additionally, introduced species may expose native species to new diseases and parasites.

3.6.4.1.4.4 Invasive Species

Native fish populations are affected by invasive (introduced, non-native) species by predation, competition, and hybridization (Moyle & Cech, 2004). Non-native fishes pose threats to native fishes when they are introduced into an environment lacking natural predators and then either compete with native marine fishes for resources or prey upon the native marine fishes (Crain et al., 2009). In the Study Area, the yellowfin goby (*Acanthogobius flavimanus*), which is native to eastern Asia, can be found in bays and estuaries.

3.6.4.1.4.5 Climate Change

Global climate change is impacting and will continue to impact marine and estuarine fish and fisheries (Intergovernmental Panel on Climate Change, 2014; Roessig et al., 2004). Climate change is contributing to a shift in fish distribution from lower to higher latitudes (Brander, 2010; Brander, 2007; Dufour et al., 2010; Popper & Hastings, 2009a; Wilson et al., 2010). Warming waters over the past quarter-century have driven fish populations in the northern hemisphere northward and to deeper depths (Inman, 2005). (Asch, 2015; 2012; Heuer & Grosell, 2014; Peterson et al., 2014)

Fishes with shifting distributions have faster life cycles and smaller body sizes than non-shifting species (Perry et al., 2005). In addition to affecting species ranges, increasing temperature has been shown to alter the sex-ratio in fish species that have temperature-dependent sex determination mechanisms (Ospina-Alvarez & Piferrer, 2008). Further temperature rises are likely to have profound impacts on commercial fisheries through continued shifts in distribution and alterations in community interactions (Perry et al., 2005). It appears that diadromous and benthic fish species are most vulnerable to climate change impacts (Hare et al., 2016).

Ocean acidification, the process whereby increasing atmospheric carbon dioxide concentrations reduces ocean pH and carbonate ion concentrations, may have serious impacts on fish development and behavior (Raven et al., 2005). Physiological development of fishes can be affected by increases in pH that can increase the size, density, and mass of fish otoliths (e.g., fish ear stones), which would affect sensory functions (Bignami et al., 2013). Ocean acidification may affect fish larvae behavior and could impact fish populations (Munday et al., 2009). A range of behavioral traits critical to survival of newly settled fish larvae are affected by ocean acidification. Settlement-stage larval marine fishes exposed to elevated carbon dioxide were less responsive to threats than controls. This decrease in sensitivity to risk might be directly related to the impaired olfactory ability (Munday et al., 2009).

Beyond direct impacts on fishes from increasing pH, ocean acidification can cause changes to the ocean chemistry, which leads to increased algal blooms (Anderson et al., 2002). Ocean acidification can also lead to reef impacts, such as coral bleaching, and can also lead to reduced larval settlement and abundance (Doropoulos et al., 2012). Plankton are important prey items for many fish species and are also impacted by ocean acidification. Ocean acidification may cause a shift in phytoplankton community composition and biochemical composition that can impact the transfer of essential compounds to predators that eat the plankton (Bermudez et al., 2016) and can cause shifts in community composition. (Anderson et al., 2002; Bermudez et al., 2016; Doropoulos et al., 2012; Fabry et al., 2008; Kroeker et al., 2013).

Another climate change effect is ocean deoxygenation. Netburn and Koslow (2015) found that the depth of the lower boundary of the deep scattering layer (so-called because the sonic pulses of a sonar can reflect off the millions of fish swim bladders) is most strongly correlated with dissolved oxygen concentration, and irradiance and oxygen concentration are the key variables determining the upper boundary. This study estimated the corresponding annual rate of change of deep scattering layer depths and hypothesized that if past trends continue, the upper boundary is expected to rise at a faster rate than the lower boundary, effectively widening the deep scattering layer. Cao et al. (2014) modeled different sensitivities of ocean temperature, carbonate chemistry, and oxygen, in terms of both the sign and magnitude to the amount of climate change. Model simulations in this study found by the year 2500, every degree increase of climate sensitivity will warm the ocean by 0.8 degree Celsius and will reduce ocean-mean dissolved oxygen concentration by 5.0 percent. Conversely, every degree increase of climate sensitivity buffers carbon dioxide-induced reduction in ocean-mean carbonate ion concentration and pH by 3.4 percent and 0.02 units, respectively. These results have great implications for understanding the response of ocean biota to climate change. Keller et al. (2015) suggested that within the California Current System, shoaling of the oxygen minimum zone is expected to produce complex changes, and onshore movement of the oxygen minimum zone could lead to habitat compression for species with higher oxygen requirements while allowing expansion of species tolerant of low-bottom dissolved oxygen.

3.6.4.1.4.6 Marine Debris

Marine debris is a widespread global pollution problem, and trends suggest that accumulations are increasing as plastic production rises (Rochman et al., 2013). Debris includes plastics, metals, rubber, textiles, derelict fishing gear, vessels, and other lost or discarded items. Debris such as abandoned nets and lines also pose a threat to fishes. Due to body shape, habitat use, and feeding strategies, some fishes are more susceptible to marine debris entanglement than others (Musick et al., 2000; Ocean Conservancy, 2010b). Entanglement in abandoned commercial and recreational fishing gear has caused declines for some marine fishes.

Microplastics (i.e., plastics less than 5mm in size) in the marine environment are well documented; and interactions with marine biota, including numerous fish species, have been described worldwide (Lusher et al., 2016). Plastic waste in the ocean chemically attracts hydrocarbon pollutants such as polychlorinated biphenyl (PCB) and dichlorodiphenyltrichloroethane, (DDT) which accumulate up to one million times more in plastic than in ocean water (Mato et al., 2001). Fishes can mistakenly consume these wastes containing elevated levels of toxins instead of their prey. Rochman et al., (2015) found marine debris in 28 percent of the individual fish examined and in 55 percent of all fish species analyzed. According to the California Coastal Commission, a state agency responsible for regulatory oversight of the California coastal zone, only 20 percent of the items found in the ocean can be linked to ocean-based sources, like commercial fishing vessels, cargo ships (discharge of containers and garbage), or pleasure cruise ships, while 80 percent of the debris is land based from sources like litter, industrial discharges, and garbage management (California Coastal Commission, 2017).

3.6.4.2 Marine Fishes in the Study Area

Taxonomic categories of the most common fish groups found in the Study Area are provided in Table 3.6-1 and described further in this section. These fish groups are based on the organization presented by Moyle and Cech (2004), Nelson (2006), Helfman et al. (2009), and Froese and Pauly (2012). These groupings are intended to organize the extensive and diverse list of fishes that occur in the Study Area and serve as a means to structure the analysis of potential impacts on fishes with similar physiological characteristics and habitat use. Exceptions to these generalizations exist within each group and are noted wherever appropriate in the analysis of potential impacts. For simplicity, the fishes are presented in generally accepted evolutionary order. Only the common taxonomic groups that have the potential to be impacted by project activities are discussed below.

Table 3.6-1: Common Taxonomic Groups of Fishes in the Point Mugu Sea Range Study Area

Major Fish Groups			***Occurrence in the Study Area***	
Group Names	***Description***	***Representative Species***	***Open Ocean***	***Coastal Waters****
Ground Sharks, Mackerel Sharks, and Bullhead Sharks (Orders Carcharhiniformes, Lamniformes, and Heterdontiformes)	Cartilaginous, two dorsal fins or first large, an anal fin, and five gill slits	Great white, Horn, Blue shark	Water column, seafloor	Water column
Frilled and Cow Sharks, Sawsharks, Dogfish, and Angel Sharks (Orders Hexanchiformes, Squaliformes, and Squatiniformes)	Cartilaginous, anal fin and nictitating membrane absent, 6–7 gill slits	Dogfish, Frill, Sevengill, Sixgill sharks	Water column, seafloor	Seafloor
Stingrays, Skates, Guitarfishes, Electric Rays and Rays (Orders Myliobatiformes, Pristiformes, Rajiformes, and Torpediniformes)	Cartilaginous, flat bodied, usually 5 gill slits	Electric, Skates, Stingrays	Water column, seafloor	Water column, seafloor
Herrings and allies (Order Clupeiformes)	Silvery, lateral line on body and fin spines absent, usually scutes along ventral profile	Anchovies, Herrings, Sardines	n/a	Surface, water column
Salmonids (Orders Salmoniformes)	Silvery body, adipose fin present	Steelhead	Water Column	Surface, water column
Silversides (Order Atheriniformes)	Protrusible upper jaw, fin spines rarely present, single dorsal fin	Grunion, Jacksmelt, Topsmelt	n/a	Water column

Table 3.6-1: Common Taxonomic Groups of Fishes in the Point Mugu Sea Range Study Area (continued)

Major Fish Groups			***Occurrence in the Study Area***	
Group Names	***Description***	***Representative Species***	***Open Ocean***	***Coastal Waters****
Scorpionfishes (Order Scorpaeniformes)	Usually strong spines on head and dorsal fin; cheeks with bony struts, pectoral fins usually rounded	Rockfishes, Sablefish, Sculpin, Greenlings	Water column, seafloor	n/a
Perch-like Fishes and Allies (Order Perciformes)	Deep bodied to moderately elongate, 1–2 dorsal fins, large mouth and eyes, and throracic pelvic fins	Groupers, Jacks, Surfperches	Water column, seafloor	Water column, seafloor
Wrasses and Allies (Order Perciformes)	Compressed body, scales large, well-developed teeth, usually colorful	Wrasses, Damselfishes	n/a	Seafloor
Blennies, Gobies, and Allies (Order Perciformes)	Body eel like to sculpin like, pelvic fins reduced or fused	Blackeye and cheekspot goby, mussel blenny	n/a	Seafloor
Tunas and Allies (Order Perciformes)	Large mouth, inlets and keels usually present, pelvic fins often absent or reduced, fast swimmers	Barracudas, Billfishes, Swordfishes, Tunas	Surface, water column	Water column for juvenile barracudas only
Flatfishes (Order Pleuronectiformes)	Body flattened, eyes on one side of body	Halibuts, Sanddabs, Soles, Tonguefishes	Seafloor	Seafloor

*Coastal Waters include bays, estuaries, and harbors.
Note: n/a = not applicable

Taxonomic groups that are associated with deep water benthic habitats are not discussed further because they would not be affected by project activities.

Species listed under the ESA are also presented under their taxonomic group. Some ESA-listed fishes, including the oceanic whitetip shark (*Carcharhinus longimanus*) and scalloped hammerhead shark (*Sphyrna lewini*), are not discussed further in this document because they have not been observed or are rarely observed in Southern California or the PMSR Study Area. Steelhead (*Oncorhynchus mykiss*) is the only ESA-listed fish species that potentially occurs in the Study Area and is discussed below.

3.6.4.2.1 Ground Sharks (Orders Carcharhiniformes), Mackerel Sharks (Order Lamniformes), and Bullhead Sharks (Order Heterodontiformes)

Ground sharks and allies (blue sharks) are cartilaginous fishes with two dorsal fins, an anal fin, five gill slits, and eyes with nictitating membranes. Reproduction includes internal fertilization with the young born fully developed. These sharks are highly migratory. They are found in the water column, open-ocean, and bottom/seafloor habitats in the Study Area. These sharks are associated with hard and soft bottoms, nearshore and open ocean surface waters, and deep sea habitats.

Mackerel sharks and allies (great white, makos) are cartilaginous fishes with a large first dorsal fin that is high, erect, and angular or somewhat rounded; anal fin with a keel; and a mouth extending behind the eyes. Reproduction includes internal fertilization with young being produced by means of eggs that are hatched within the body of the female. They are found in the water column and bottom/seafloor habitats in the California Current and open ocean areas. These sharks are associated with nearshore and open ocean surface water habitats. Ground and mackerel sharks are efficient predators on large fishes, cephalopods, and marine mammals. Some species are targeted for commercial and recreational purposes.

Bullhead sharks and allies (horn shark) are cartilaginous fishes with two dorsal fins, an anal fin, five gill slits, and eyes without nictitating membranes. Reproduction includes internal fertilization with egg cases laid in crevices. They are found in the soft bottom/seafloor habitat in the Study Area. Horn sharks (*Heterodontus francisci*) are also infrequently observed in kelp forests off of SNI (Kenner, 2018).

3.6.4.2.2 Frilled and Cow Sharks (Order Hexanchiformes), Dogfish Sharks (Order Squaliformes), and Angel Sharks (Order Squatiniformes)

Frill and cow sharks (sevengill, sixgill) are cartilaginous fishes, generally characterized by lacking traits such as an anal fin and nictitating membrane; they do possess six to seven gill slits, compared to five gill slits found in all other sharks. Reproduction includes internal fertilization with young being produced by means of eggs that are hatched within the body of the female. They are associated with deep sea habitats in the Study Area (Froese & Pauly, 2012; Moyle & Cech, 2004).

Dogfish sharks are cartilaginous fishes with two dorsal fins spines and a caudal fin that is divided into two lobes: a larger dorsal lobe and a smaller ventral lobe. Reproduction includes internal fertilization with young emerging from eggs that are hatched within the body of the female. They are associated with soft bottom and deep-sea habitats in the Study Area (Froese & Pauly, 2012; Moyle & Cech, 2004).

Angel sharks (e.g., Pacific angel shark) are cartilaginous fishes with flat, batoid-like body, two small spineless dorsal fins behind pelvic fins, and anal fin absent. Reproduction includes internal fertilization with young emerging from eggs that are hatched within the body of the female. They are associated with soft bottom habitat in the Study Area (Froese & Pauly, 2012; Moyle & Cech, 2004).

3.6.4.2.3 Stingrays and Allies (Order Myliobatiformes), Skates and Guitarfishes (Order Rajiformes), and Electric Rays (Order Torpediniformes)

Stingrays and allies (bat ray) are cartilaginous fishes, distinguished by flattened bodies, enlarged pectoral fins that are fused to the head, and gill slits that are placed on their ventral surfaces. Reproduction includes internal fertilization with the young born fully developed. They are associated with reefs, nearshore open ocean, inland waters, and deep sea water column habitat in the Study Area (Froese & Pauly, 2012; Moyle & Cech, 2004).

Skates and guitarfishes are cartilaginous fishes, distinguished by flattened bodies, two reduced dorsal fins, and a reduced caudal fin. Reproduction includes internal fertilization and deposition of egg sacks. They are associated with soft bottom habitat in the Study Area (Froese & Pauly, 2012; Moyle & Cech, 2004).

Electric rays are cartilaginous fishes, distinguished by flattened bodies, two well-developed dorsal fins and caudal fin. Two large kidney-shaped organs in a disc on either side of the electric ray's head distinguish it from others, as these organs are able to produce strong electric shock at will (Madl & Yip, 2000). Reproduction includes internal fertilization with young being produced by means of eggs that are hatched within the body of the female. Only one species of electric ray, the Pacific electric ray (*Torpedo californica*), occurs in the Study Area.

3.6.4.2.4 Herrings (Order Clupeiformes)

Herring and allies (anchovies, herrings, sardines, and shad) are bony fishes with a silvery body with the lateral line and fin spines absent, and usually scutes along ventral profile. They are found only in the marine environment in the water column and in seafloor habitats in the Study Area. Herring, menhaden, sardine, and anchovy species are well known as valuable targets of commercial fisheries. Herring account for a large portion of the total worldwide fish catch (Food and Agriculture Organization of the United Nations, 2005, 2009). Herrings and allies are broadcast spawners. They are known to form schools to help conserve energy and minimize predation (Brehmer et al., 2007), which may facilitate some level of communication during predator avoidance (Marras et al., 2012). They feed on decaying organic matter and plankton while swimming in the water column (Moyle & Cech, 2004). Herring and allies support marine food webs as a forage fish and are preyed upon by fish, birds, and marine mammals.

3.6.4.2.5 Salmonids (Order Salmoniformes)

This group of fishes includes all salmon, trout, and chars. The only representative species in the Study Area is the ocean-migrating (anadromous) form of rainbow trout or steelhead (Myers, 2018).

3.6.4.2.5.1 Steelhead (*Oncorhynchus mykiss*)

<u>Status and Management</u>

Steelhead are federally protected by the designation of distinct population segments (DPSs). Of the 15 steelhead DPSs, one DPS is listed as endangered under the ESA, and 10 DPSs and one experimental non-essential population are listed as threatened (National Marine Fisheries Service, 2019). NMFS listed the Southern California DPS of steelhead as endangered in 1997 (National Marine Fisheries Service, 1997). The Southern California Coast DPS range for steelhead extends from Santa Maria River south to San Mateo Creek and includes streams south of Malibu Creek, specifically Topanga and San Mateo Creeks (National Marine Fisheries Service, 2002). Steelhead in the South Central California Coast DPS occur from the Pajaro River in Monterey County south to the Santa Maria River, but not including the Santa Maria River. Therefore, steelhead in the Study Area most likely are members of the Southern California Coast DPS.

Critical habitat was designated for areas occupied by steelhead at the time of listing. Critical Habitat does not occur within the PMSR Study Area (Figure 3.6-1). The Calleguas Creek watershed and Naval Base Ventura County Point Mugu are also outside critical habitat boundaries for Southern California coast steelhead (70 *Federal Register* 52488).

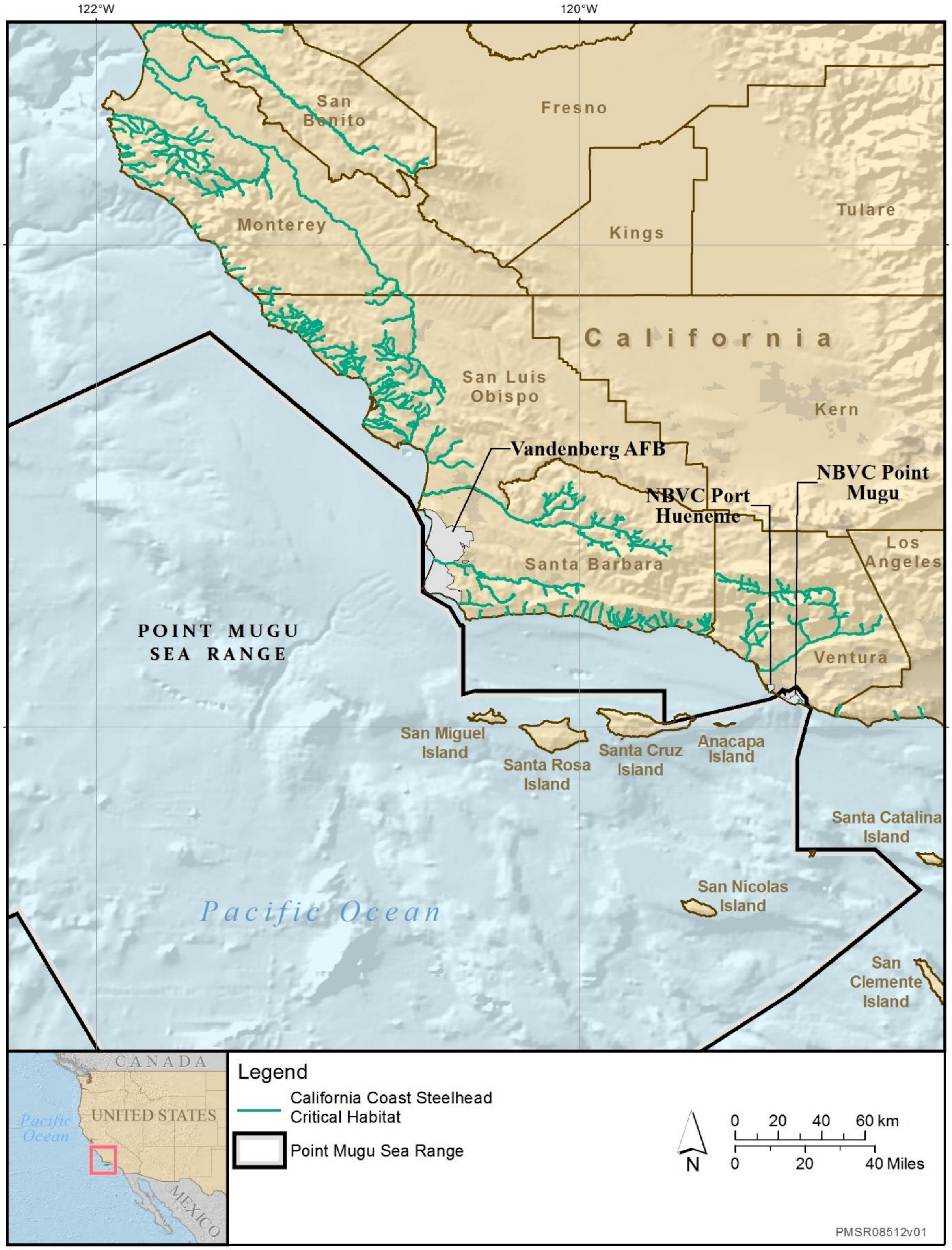

Figure 3.6-1: Designated Steelhead Critical Habitat in the Vicinity of the PMSR Study Area

Habitat and Geographic Range

The natural range of anadromous steelhead includes the Pacific coast of the United States to Southern California (Good et al., 2005), but it is being introduced throughout the world.

Spawning and rearing habitat are not described since both occur outside of the Study Area (2012). Adult steelhead can migrate up to 930 miles from their ocean habitats to reach their freshwater spawning grounds in high elevation tributaries. This species has not been recorded in Mugu Lagoon, but it has historically occurred in the Ventura and Santa Clara Rivers north of Naval Base Ventura County Point Mugu and has not been documented in Calleguas Creek (U.S. Department of the Navy, 2013). On April 26, 2013, a dead gravid steelhead trout was discovered during a flow rate survey on Conejo Creek, a tributary of Calleguas Creek (Hovey & O'Brien, 2013). Migrating steelhead adults that move through the mouth of Mugu Lagoon en route to Calleguas Creek, and smolt which may utilize the estuary before heading out to sea, could be affected by habitat conditions in the Mugu estuary.

Although information on the ocean distribution and abundance of steelhead is lacking, it is likely that this species is present in the Study Area. Throughout their extensive oceanic range, steelhead are thought to be sparsely distributed and their abundances in research catches is extremely low (Myers, 2018). There is also considerable variation in this life history pattern within the population, partly due to Southern California’s variable seasonal and annual climatic conditions. Some winters produce heavy rainfall and flooding, which allow juvenile steelhead easier access to the ocean, while dry seasons may close the mouths of coastal streams, limiting juvenile steelheads’ access to marine waters (National Marine Fisheries Service, 1997).

Population Trends

Steelhead stocks have declined substantially from their historic numbers, and many now are threatened with extinction. Native lineages have been nearly extirpated from the southern region of the native range, with only a few relict populations persisting in the headwaters of the San Gabriel, Santa Ana, and San Luis Rey rivers (National Marine Fisheries Service, 2016a). Abadia-Cardoso et al. (2016) documented that the majority of steelhead sampled between Southern California watersheds and Mexico were genetically related to hatchery rainbow trout. This may indicate either replacement of native steelhead or hybridization with native steelhead in Southern California.

Most of the steelhead DPSs, including the Southern California Coast DPS, have a low abundances relative to historical levels, and there is widespread occurrence of hatchery fish in naturally spawning populations (Good et al., 2005; National Marine Fisheries Service, 2010b, 2012). NMFS has reported population sizes from individual DPSs, but because all of these units occur together while at sea, it is difficult to estimate the marine population numbers.

Predator and Prey Interactions

Steelhead predators include birds, such as terns and cormorants, and marine mammals, such as sea lions and harbor seals (National Marine Fisheries Service, 2010b). Juveniles in freshwater feed mostly on zooplankton (small animals that drift in the water), while adults feed on aquatic and terrestrial insects, molluscs, crustaceans, fish eggs, minnows, and other small fishes, including other trout and salmon, depending on whether they are inhabiting streams or the ocean (National Marine Fisheries Service, 2010b).

Species-Specific Threats

Most of the threats to Southern California steelhead occur outside the Study Area and include alteration of stream flow patterns and habitat degradation, barriers to fish passage, channel alterations, water quality problems, non-native fishes and plants, and climate change.

3.6.4.2.6 Silversides (Order Atheriniformes)

Silversides (grunion, jacksmelt, and topsmelt) are bony fishes with a silvery stripe on their sides, high pectoral fins, a dorsal fin, and a pelvic fin with a spine. These fishes are found on the surface and in the water column throughout the Study Area. This group of fishes are typically small, translucent, have a protractible upper jaw, form small to large schools near the surfaces, and are usually omnivores or planktivores (Kells et al., 2016).

3.6.4.2.7 Scorpionfishes (Order Scorpaeniformes)

Scorpionfishes and allies (poachers, rockfishes, snailfishes, and sculpins) are bony fishes with usually strong spines on head and dorsal fin, cheeks with bony struts, and rounded pectoral fins. Venom glands are usually present at the base of the dorsal, pelvic, and anal fins (Kells et al., 2016). These fishes are associated with numerous habitats, including open ocean and water column, hard and soft bottom, reefs, and deep sea benthic habitats in the Study Area (Froese & Pauly, 2012; Paxton & Eschmeyer, 1998). Some scorpionfishes have commercial and recreation fishery importance (Moyle & Cech, 2004). Reproduction methods vary widely between species and include external fertilization and egg deposition (sculpins) and internal fertilization and bearing live young (rockfishes). Most fishes in this group are diurnal ambush predators and prey on bottom-dwelling invertebrates and small fishes. Scorpionfishes are allies are preyed upon by larger fishes, birds, and marine mammals. A suite of rockfishes, including blue (*Sebastes mystinus*), olive (*S. serranoides*) and kelp (*S. atrovirens*), are commonly observed in the kelp beds off SNI (Kenner, 2018; Kenner & Tomoleoni, 2020).

3.6.4.2.8 Order Perciformes

Perciforms are the largest order of vertebrates, with over 7,800 species. They are extremely diverse, but most species are adapted for life as predators in the shallow or surface waters of the ocean. Some of the characteristics include fin spines present, dorsal fins either double or made up of two distinct parts with the lead spiny, adipose fin absent, pelvic fins thoracic or jugular in position or absent, pectoral fins on side of body, ctenoid scales, and closed swim bladder. Nearly half of all species belong to four families: gobies, wrasses, seabasses, or blennies (Moyle & Cech, 2004). Fish groupings in this section generally follow the classification in Nelson (2016).

3.6.4.2.8.1 Perches and Allies

Perches and allies (grunts, jacks, sea basses, striped bass, and surfperches) are bony fishes with deep to moderately elongate bodies, one to two dorsal fins, large mouth and eyes and thoracic pelvic fins. These fishes are associated with open ocean areas, hard and soft bottom, reefs, submerged aquatic vegetation, open ocean, and deep sea habitats in the Study Area (Froese & Pauly, 2012; Moyle & Cech, 2004). Common species found in the kelp forests at SNI includes kelp bass (*Paralabrax clathratus*) and black perch (*Embiotoca jacksoni*) (Kenner, 2018; Kenner & Tomoleoni, 2020).

3.6.4.2.8.2 Wrasses and Allies

Wrasses and allies (wrasses and damselfishes) are bony fishes with a compressed body, large scales, well-developed teeth, and usually colorful coloring. Some wrasses and allies have recreational fishery and aquarium trade importance. Most of these fishes are associated with depths less than 30 m hard and soft bottom and reef habitats in the Study Area (Froese & Pauly, 2012; Moyle & Cech, 2004). Wrasses and allies can change sex, usually female-to-male, and exhibit broadcast spawning; the fertilized eggs float in the water column or attach to substrate until hatching into larvae. Most are diurnal opportunistic predators (Wainwright & Richard, 1995). Prey items include zooplankton, invertebrates, and small fishes. Predators of wrasses and allies include larger fishes and marine mammals. Schooling species such as blacksmith (*Chromis punctipinnis*) and señorita (*Oxyjulius californica*) made up the vast majority of fish counts within the kelp beds around SNI (Kenner, 2018; Kenner & Tomoleoni, 2020). The California sheephead (*Semicossyphus pulcher*) is also commonly observed in the kelp beds around SNI (Kenner, 2018; Kenner & Tomoleoni, 2020).

3.6.4.2.8.3 Blennies, Gobies, and Allies

Blennies, gobies, and allies (blackeye goby, cheekspot goby, mussel blenny) are bony fishes with an eel-like to sculpin-like body, and pelvic fins reduced or fused. They are associated with hard and soft bottoms, reefs, and deep sea habitats in the Study Area (Froese & Pauly, 2012). The lateral line and scales on gobies are absent, and they are one of the most diverse groups of reef fishes (Kells et al., 2016).

3.6.4.2.8.4 Tunas and Allies

The tuna and allies (barracudas, billfishes, swordfishes, and tunas) have a large mouth, keels usually present, and pelvic fins often absent or reduced; and they are fast swimmers. These fishes are associated with reefs, nearshore, and offshore open ocean habitats in the Study Area (Froese & Pauly, 2012; Moyle & Cech, 2004). Most species have commercial and recreational importance. Tuna and allies are voracious open ocean predators (Estrada et al., 2003). They exhibit broadcast spawning and fertilized eggs float in the water column until hatching into larvae. Many feed nocturnally (Goatley & Bellwood, 2009) and in low-light conditions of twilight (Rickel & Genin, 2005). Many species in this group make large-scale migrations that allow for feeding in highly productive areas, which vary by season (Pitcher, 1995). Prey items include zooplankton for larvae and juvenile stages, while fishes and squid are consumed by subadults and adults. Predators of tuna and allies include other tuna species, billfishes, toothed whales, and some open ocean shark species.

3.6.4.2.9 Flatfishes (Order Pleuronectiformes)

Flatfishes (flounders, halibut, sand dabs, soles, and tonguefish) are bony fishes with a flattened body and eyes on one side of body. These fishes occur on soft bottom habitat in inland waters, as well as in deep sea habitats in the Study Area, and are an important part of commercial fisheries in the Study Area. The California halibut (*Paralichthys californicus*) is a representative of this group and is a recreationally fished species. Flatfishes are broadcast spawners. They are ambush predators, preying on other fishes and bottom-dwelling invertebrates. Some species in this group have been affected by overfishing (Drazen & Seibel, 2007; Froese & Pauly, 2010).

3.6.5 Environmental Consequences

The U.S. Navy considered all potential stressors that would potentially impact marine fishes. This section evaluates how and to what degree the activities described in Chapter 2 (Description of Proposed Action and Alternatives) and Section 3.0.5 (Overall Approach to Analysis) could impact marine fishes, as defined in this section in the Study Area. A comparison of the baseline annual operational tempo and the proposed Action Alternatives is presented in Table 2-2. Table 3.6-2 presents the proposed testing and training activities and stressors that could potentially affect marine fishes. The stressors analyzed for marine fishes include explosives, physical disturbance and strike, energy, and ingestion.

Table 3.6-2: Summary of Stressors Analyzed for Marine Fishes from Testing and Training Activities Within the Study Area

Activity Category	Stressor	Potential Impacts	ESA Determination
Air-to-Air	Physical Disturbance/Strike	While disturbance or strike from any military expended material as they sink through the water column is possible, it is not very likely for most expended materials because the objects generally sink through the water slowly and can be avoided by most, if not all, fishes.	Not likely to adversely affect ESA-listed steelhead
	Ingestion	Ingestion of military expended materials could result in sublethal or lethal impacts on fishes. However, the likelihood of ingestion is low based on the dispersed nature of the materials and the limited exposure of those items at the surface/water column where fewer fishes occur.	Not likely to adversely affect ESA-listed steelhead
Air-to-Surface	Explosives	Sound and energy from explosions could cause physiological and behavioral reactions in marine fishes. Although individuals may be impacted, long-term consequences for populations would not be expected.	Not likely to adversely affect ESA-listed steelhead
	Physical Disturbance/Strike	While disturbance or strike from any military expended material as they sink through the water column is possible, it is not very likely for most expended materials because the objects generally sink through the water slowly and can be avoided by most, if not all, fishes.	Not likely to adversely affect ESA-listed steelhead
	Ingestion	Ingestion of military expended materials could result in sublethal or lethal impacts on fishes. However, the likelihood of ingestion is low based on the dispersed nature of the materials and the limited exposure of those items at the surface/water column where fewer fishes occur.	Not likely to adversely affect ESA-listed steelhead

Table 3.6-2: Summary of Stressors Analyzed for Marine Fishes from Testing and Training Activities Within the Study Area (continued)

Activity Category	Stressor	Potential Impacts	ESA Determination
Surface-to-Air	Energy – high-energy lasers	Most fishes are unlikely to be exposed to high-energy laser activities because they primarily occur more than a few meters below the sea surface.	Not likely to adversely affect ESA-listed steelhead
	Physical Disturbance/Strike	While disturbance or strike from any military expended material as they sink through the water column is possible, it is not very likely for most expended materials because the objects generally sink through the water slowly and can be avoided by most, if not all, fishes.	Not likely to adversely affect ESA-listed steelhead
	Ingestion	Ingestion of military expended materials could result in sublethal or lethal impacts on fishes. However, the likelihood of ingestion is low based on the dispersed nature of the materials and the limited exposure of those items at the surface/water column where fewer fishes occur.	Not likely to adversely affect ESA-listed steelhead
Surface-to-Surface	Explosives	Sound and energy from explosions could cause physiological and behavioral reactions in marine fishes. Although individuals may be impacted, long-term consequences for populations would not be expected.	Not likely to adversely affect ESA-listed steelhead
	Energy – high-energy lasers	Most fishes are unlikely to be exposed to high-energy laser activities because they primarily occur more than a few meters below the sea surface.	Not likely to adversely affect ESA-listed steelhead
	Physical Disturbance/Strike	While disturbance or strike from any military expended material as they sink through the water column is possible, it is not very likely for most expended materials because the objects generally sink through the water slowly and can be avoided by most, if not all, fishes.	Not likely to adversely affect ESA-listed steelhead
	Ingestion	Ingestion of military expended materials could result in sublethal or lethal impacts on fishes. However, the likelihood of ingestion is low based on the dispersed nature of the materials and the limited exposure of those items at the surface/water column where fewer fishes occur.	Not likely to adversely affect ESA-listed steelhead

Table 3.6-2: Summary of Stressors Analyzed for Marine Fishes from Testing and Training Activities Within the Study Area (continued)

Activity Category	Stressor	Potential Impacts	ESA Determination
Subsurface-to-Surface	Explosives	Sound and energy from explosions could cause physiological and behavioral reactions in marine fishes. Although individuals may be impacted, long-term consequences for populations would not be expected.	Not likely to adversely affect ESA-listed steelhead
	Energy – high-energy lasers	Most fishes are unlikely to be exposed to high-energy laser activities because they primarily occur more than a few meters below the sea surface.	Not likely to adversely affect ESA-listed steelhead
	Physical Disturbance/Strike	While disturbance or strike from any military expended material as they sink through the water column is possible, it is not very likely for most expended materials because the objects generally sink through the water slowly and can be avoided by most, if not all, fishes.	Not likely to adversely affect ESA-listed steelhead
	Ingestion	Ingestion of military expended materials could result in sublethal or lethal impacts on fishes. However, the likelihood of ingestion is low based on the dispersed nature of the materials and the limited exposure of those items at the surface/water column where fewer fishes occur.	Not likely to adversely affect ESA-listed steelhead
Electronic Warfare	Energy – high-energy lasers	Most fishes are unlikely to be exposed to high-energy laser activities because they primarily occur more than a few meters below the sea surface.	Not likely to adversely affect ESA-listed steelhead
	Physical Disturbance/Strike	While disturbance or strike from any military expended material as they sink through the water column is possible, it is not very likely for most expended materials because the objects generally sink through the water slowly and can be avoided by most, if not all, fishes.	Not likely to adversely affect ESA-listed steelhead
	Ingestion	Ingestion of military expended materials could result in sublethal or lethal impacts on fishes. However, the likelihood of ingestion is low based on the dispersed nature of the materials and the limited exposure of those items at the surface/water column where fewer fishes occur.	Not likely to adversely affect ESA-listed steelhead

Table 3.6-2: Summary of Stressors Analyzed for Marine Fishes from Testing and Training Activities Within the Study Area (continued)

Activity Category	Stressor	Potential Impacts	ESA Determination
Directed Energy Weapons	Energy – high-energy lasers	Most fishes are unlikely to be exposed to high-energy laser activities because they primarily occur more than a few meters below the sea surface.	Not likely to adversely affect ESA-listed steelhead
	Physical Disturbance/Strike	While disturbance or strike from any military expended material as they sink through the water column is possible, it is not very likely for most expended materials because the objects generally sink through the water slowly and can be avoided by most, if not all, fishes.	Not likely to adversely affect ESA-listed steelhead
	Ingestion	Ingestion of military expended materials could result in sublethal or lethal impacts on fishes. However, the likelihood of ingestion is low based on the dispersed nature of the materials and the limited exposure of those items at the surface/water column where fewer fishes occur.	Not likely to adversely affect ESA-listed steelhead

Note: ESA = Endangered Species Act

Stressors such as acoustic (vessel noise, aircraft noise, and weapons noise) and entanglement were analyzed in several previous Navy environmental documents (U.S. Department of the Navy, 2018a, 2018b) and determined to have negligible impacts on marine fishes. For acoustics, this is due to the small area within which sound could potentially enter the water and the extremely brief window the sound could be present. Exposures to aircraft noise would be extremely rare and, in the event that they did occur, would be very brief (seconds). Fish would not be susceptible to entanglement because the encounter rate for decelerators/parachutes is extremely low and the physical characteristics of the expended materials (e.g., decelerators/parachutes) reduces entanglement risk to fishes compared to monofilament used for fishing gear.

A summary of potential impacts on federally managed fish species and essential fish habitat from proposed Navy testing and training activities is presented in Chapter 6 (Other Regulatory Considerations).

Proposed Navy activities such as subsurface-to-surface testing would not impact marine fishes since this activity takes place in the upper water column, and fish are highly mobile and would be able to avoid components of this testing event. The risk of a strike from vessels and surface targets used in testing activities would be low because (1) most fishes can detect and avoid vessel and surface target movements, and (2) the types of fish that are likely to be exposed to vessel and surface target strikes are limited (such as whale sharks and ocean sunfishes) and occur in low concentrations where vessels and surface targets are most frequently used. Other stressors such as weapons noise and aircraft noise have been analyzed in several previous Navy environmental documents (U.S. Department of the Navy, 2018a, 2018b) and were determined to not substantially affect marine fishes.

3.6.5.1 No Action Alternative

Under the No Action Alternative, proposed testing and training activities would not occur within the PMSR. Other military activities not associated with this Proposed Action would continue to occur. Stressors such as explosives, energy, physical disturbance/strike, and ingestion, as listed above, would not be introduced into the marine environment. Therefore, existing environmental conditions would either remain unchanged or would improve slightly after cessation of ongoing testing and training activities.

Discontinuing the testing and training activities would result in fewer stressors within the marine environment where testing and training activities have historically been conducted. Therefore, discontinuing testing and training activities under the No Action Alternative would lessen the potential for impacts on marine fishes, but would not measurably improve the overall distribution or abundance of marine fishes.

3.6.5.2 Alternative 1 (Preferred Alternative)

3.6.5.2.1 Explosives

Explosions near the water surface can introduce loud, impulsive, broadband sounds into the marine environment. However, unlike other acoustic stressors, explosives release energy at a high rate, producing a shock wave that can be injurious and even deadly. Explosives are usually described by their net explosive weight, which accounts for the weight and type of explosive material. The ways in which an explosive exposure could result in immediate effects or lead to long-term consequences for a fish are explained below.

3.6.5.2.1.1 Background

The effects of explosions on fishes have been studied and reviewed by numerous authors (Keevin & Hempen, 1997; O'Keeffe, 1984; O'Keeffe & Young, 1984; Popper et al., 2014). A summary of the literature related to each type of effect forms the basis for analyzing the potential effects from Navy activities. The sections below include a survey and synthesis of best-available-science published in peer-reviewed journals, technical reports, and other scientific sources pertinent to impacts on fishes potentially resulting from Navy testing and training activities. Fishes could be exposed to a range of impacts depending on the explosive source and context of the exposure. In addition to acoustic impacts, including temporary or permanent hearing loss, auditory masking, physiological stress, or changes in behavior, potential impacts from an explosive exposure can include non-lethal injury and mortality.

Injury

Injury refers to the direct effects on the tissues or organs of a fish. The blast wave from an in-water explosion is lethal to fishes at close range, causing massive organ and tissue damage (Keevin & Hempen, 1997). At greater distance from the detonation point, the extent of mortality or injury depends on a number of factors, including fish size, body shape, depth, physical condition of the fish, and perhaps most importantly, the presence of a swim bladder (Keevin & Hempen, 1997; Wright, 1982; Yelverton & Richmond, 1981; Yelverton et al., 1975). At the same distance from the source, larger fishes are generally less susceptible to death or injury, elongated forms that are round in cross-section are less at risk than deep-bodied forms, and fishes oriented sideways to the blast suffer the greatest impact (Edds-Walton & Finneran, 2006; O'Keeffe, 1984; O'Keeffe & Young, 1984; Wiley et al., 1981; Yelverton et al., 1975). Species with a swim bladder are much more susceptible to blast injury from explosives than fishes without them (Gaspin, 1975; Gaspin et al., 1976; Goertner et al., 1994).

If a fish is close to an explosive detonation, the exposure to rapidly changing high pressure levels can cause barotrauma. Barotrauma is injury due to a sudden difference in pressure between an air space inside the body and the surrounding water and tissues. Rapid compression followed by rapid expansion of airspaces, such as the swim bladder, can damage surrounding tissues and result in the rupture of the airspace itself. The swim bladder is the primary site of damage from explosives (Wright, 1982; Yelverton et al., 1975). Gas-filled swim bladders resonate at different frequencies than surrounding tissue and can be torn by rapid oscillation between high- and low-pressure waves (Goertner, 1978). Swim bladders are a characteristic of most bony fishes, with the notable exception of flatfishes (e.g., halibut). Sharks and rays are examples of fishes without a swim bladder. Small airspaces, such as micro-bubbles that may be present in gill structures, could also be susceptible to oscillation when exposed to the rapid pressure increases caused by an explosion. This may have caused the bleeding observed on gill structures of some fish exposed to explosions (Goertner et al., 1994). Sudden very high pressures can also cause damage at tissue interfaces due to the way pressure waves travel differently through tissues with different densities. Rapidly oscillating pressure waves might rupture the kidney, liver, spleen, and sinus and cause venous hemorrhaging (Keevin & Hempen, 1997).

Several studies have exposed fish to explosives and examined various metrics in relation to injury susceptibility. Hubbs and Rechnitzer (1952) showed that fish with swim bladders exposed to explosive shock fronts (the near-instantaneous rise to peak pressure) were more susceptible to injury when several feet below the water surface than near the bottom. When near the surface, the fish began to exhibit injuries around peak pressure exposures of 40–70 pounds per square inch. However, near the bottom (all water depths were less than 100 feet) fish exposed to pressures over twice as high exhibited no sign of injury. Yelverton et al. (1975) similarly found that peak pressure was not correlated to injury susceptibility but was correlated to the metric of positive impulse (pascal seconds), which takes into account both the positive peak pressure, the duration of the positive pressure exposure, and the fish mass, with smaller fish being more susceptible.

Gaspin et al. (1976) exposed multiple species of fish with a swim bladder, placed at varying depths, to explosive blasts of varying size and depth. Goertner (1978) and Wiley (1981) developed a swim bladder oscillation model, which showed that the severity of injury observed in those tests could be correlated to the extent of swim bladder expansion and contraction predicted to have been induced by exposure to the explosive blasts. Per this model, the degree of swim bladder oscillation is affected by ambient pressure (i.e., depth of fish), peak pressure of the explosive, duration of the pressure exposure, and exposure to surface rarefaction (negative pressure) waves. The maximum potential for injury is predicted to occur where the surface reflected rarefaction (negative) pressure wave arrives coincident with the moment of maximum compression of the swim bladder caused by exposure to the direct positive blast pressure wave, resulting in a subsequent maximum expansion of the swim bladder. Goertner (1978) and Wiley et al. (1981) found that their swim bladder oscillation model explained the injury data in the Yelverton et al. (1975) exposure study, and their impulse parameter was applicable only to fishes at shallow enough depths to experience less than one swim bladder oscillation before being exposed to the following surface rarefaction wave.

O'Keeffe (1984) provides calculations and contour plots that allow estimation of the range to potential effects of in-water explosions on fish possessing swim bladders, using the damage prediction model developed by Goertner (1978). O'Keeffe's (1984) parameters include the charge weight, depth of burst, and the size and depth of the fish, but the estimated ranges do not take into account unique propagation environments that could reduce or increase the range to effect. The 10 percent mortality range is the maximum horizontal range predicted by O'Keeffe (1984) for 10 percent of fish suffering injuries that are expected to not be survivable (e.g., damaged swim bladder or severe hemorrhaging). Fish at greater depths and near the surface are predicted to be less likely to be injured because geometries of the exposures would limit the amplitude of swim bladder oscillations.

Studies that have documented caged fishes killed during planned in-water explosions indicate that most fish that die do so within one to four hours, and almost all die within a day (Yelverton et al., 1975). Mortality in free-swimming (uncaged) fishes may be higher due to increased susceptibility to predation. Fitch and Young (1948) found that the type of free-swimming fish killed changed when blasting was repeated at the same location within 24 hours of previous blasting. They observed that most fish killed on the second day were scavengers, presumably attracted by the victims of the previous day’s blasts.

Hearing Loss

There are no direct measurements of hearing loss in fishes due to exposure to explosive sources. The sound resulting from an explosive detonation is considered an impulsive sound and shares important qualities (i.e., short duration and fast rise time) with other impulsive sounds. Permanent Threshold Shift in fish has not been known to occur in species tested to date, and any hearing loss in fish may be as temporary as the timeframe required to repair or replace the sensory cells that were damaged or destroyed (Popper et al., 2014; Popper et al., 2005; Smith et al., 2006).

As reviewed in Popper et al. (2014), fishes without a swim bladder such as sharks and rays, or fishes with a swim bladder not involved in hearing (e.g., rockfishes), would be less susceptible to hearing loss (i.e., Temporary Threshold Shift), even at higher-level exposures. Fish with a swim bladder involved in hearing, such as anchovy and sardines, may be susceptible to Temporary Threshold Shift within very close ranges to an explosive.

Masking

There are no direct observations of masking in fishes due to exposure to explosives. Popper et al., (2014) highlights a lack of data that exist for masking by explosives but suggests that the intermittent nature of explosions would result in very limited probability of any masking effects and, if masking occurred, it would only occur during the duration of the sound.

Physiological Stress

Fishes naturally experience stress within their environment and as part of their life histories. The stress response is a suite of physiological changes that are meant to help an organism mitigate the impact of a stressor. However, if the magnitude and duration of the stress response is too great or too long, then it can have negative consequences to the organism (e.g., decreased immune function, decreased reproduction).

Research on physiological stress in fishes due to exposure to explosive sources is limited. Sverdrup et al. (1994) studied levels of stress hormones in Atlantic salmon after exposure to multiple detonations in a laboratory setting. Increases in cortisol and adrenaline were observed following the exposure, with adrenaline values returning to within normal range within 24 hours. Generally, stress responses are more likely to occur in the presence of potentially threatening sound sources such as predator vocalizations or the sudden onset of impulsive signals. Stress responses may be brief (a few seconds to minutes) if the exposure is short or if fishes habituate or learn to tolerate the noise. It is assumed that any physiological response (e.g., hearing loss or injury) or significant behavioral response is also associated with a stress response.

Behavioral Reactions

Any stimuli in the environment can cause a behavioral response in fishes, including sound and energy produced by explosions. Behavioral reactions of fishes to explosions have not been recorded. Behavioral reactions from explosive sounds are likely to be similar to reactions studied for other impulsive sounds, such as those produced by air guns. Impulsive signals, particularly at close range, have a rapid rise time and higher instantaneous peak pressure than other signal types, making them more likely to cause startle or avoidance responses.

Popper et al., (2014) describes how fish species may react differently to the same sound source depending on a number of variables, such as the animal's life stage or behavioral state (e.g., feeding, mating). Without data that are more specific it is assumed that fishes with similar hearing capabilities react similarly to all impulsive sounds outside or within the zone for hearing loss and injury. Observations of fish reactions to large-scale air gun surveys are informative, but not necessarily directly applicable to analyzing impacts from the short-term, intermittent use of all impulsive sources. Fish have a higher probability of reacting when closer to an impulsive sound source (within tens of meters), and a decreasing probability of reaction at increasing distances (Popper et al., 2014).

Long-Term Consequences

Long-term consequences to a population are determined by examining changes in the population growth rate. Physical effects from explosive sources that could lead to a reduction in the population growth rate include mortality or injury, which could remove animals from the reproductive pool, and permanent hearing impairment or chronic masking, which could affect navigation, foraging, predator avoidance, or communication. The long-term consequences due to individual behavioral reactions, masking, and short-term instances of physiological stress are especially difficult to predict because individual experience over time can create complex contingencies, especially for fish species that live for multiple seasons or years. For example, a lost reproductive opportunity could be a measurable cost to the individual; however, short-term costs may be recouped during the life of an otherwise healthy individual. These factors are taken into consideration when assessing risk of long-term consequences.

Thresholds for the onset of injury from exposure to explosives are not currently available, and recommendations by Popper et al., (2014) only provide qualitative criteria for consideration. Therefore, available data from existing explosive studies were reviewed to provide a conservative estimate for a threshold to the onset of injury (Gaspin, 1975; Gaspin et al., 1976; Govoni et al., 2003; Govoni et al., 2008; Hubbs & Rechnitzer, 1952; Settle et al., 2002; Yelverton et al., 1975). It is important to note that some of the available literature is not peer reviewed and may have some caveats to consider when reviewing the data (e.g., issues with controls, limited details on injuries observed), but this information may still provide a better understanding of where injurious effects would begin to occur specific to explosive activities. The lowest thresholds at which injuries were observed in each study were recorded and compared for consideration in selecting criteria. As a conservative measure, the absolute lowest peak sound pressure level recorded that resulted in injury, observed in exposures of larval fishes to explosions (Settle et al., 2002), was selected to represent the threshold to injury.

The injury threshold is consistent across all fish, regardless of hearing group, due to the lack of rigorous data for multiple species. It is important to note that these thresholds may be overly conservative as there is evidence that fishes exposed to higher thresholds have shown no signs of injury (depending on variables such as the weight of the fish, size of the explosion, and depth of the cage). It is likely that adult fishes and fishes without a swim bladder would be less susceptible to injury than more sensitive hearing groups and larval species.

The number of fish killed by an in-water explosion would depend on the population density near the blast, as well as factors discussed above, such as net explosive weight, depth of the explosion, and fish size. For example, if an explosion occurred in the middle of a dense school of sardines, anchovy, or other schooling fish, a large number of fish could be killed. However, the probability of this occurring is low based on the patchy distribution of dense schooling fish. Stunning from pressure waves could also temporarily immobilize fish, making them more susceptible to predation.

Under Alternative 1, fishes would be exposed to surface explosions and associated underwater impulsive sounds from high-explosive munitions such as bombs and missiles during air-to-surface and surface-to-surface activities. Explosives would be used throughout the Study Area. A discussion of explosives, including explosive source classes, is provided in Section 3.0.5.6 (Explosive Stressors). There would be an overall increase in the number of explosions under Alternative 1 compared to current environmental baseline conditions (see Table 3.0-7). Sound and energy from explosions could result in mortality and injury, including hearing loss in nearby fishes. Generally, explosives that belong to larger bins (with large net explosive weights) produce longer ranges within each effect category. However, some ranges vary depending upon a number of other factors (e.g., number of explosions in a single activity). Fishes without a swim bladder, adult fishes, and larger species would generally be less susceptible to injury and mortality from sound and energy associated with explosive activities than small, juvenile, or larval fishes. Fishes that experience hearing loss could miss opportunities to detect predators or prey, or show a reduction in interspecific communication. Because explosions from Navy testing and training activities would be concentrated at the water's surface, only pelagic species and more surface-oriented species would be impacted by explosions. Overall, the number of fish species affected by explosions would be low compared to the total number of fish species in Study Area. Therefore, potential impacts from explosions to fishes under Alternative 1 would be less than significant.

Potential impacts on ESA-listed steelhead from testing and training activities using surface explosives are possible, but highly unlikely, primarily due to low population numbers in Southern California (Boughton et al., 2006). In addition, information on the ocean distribution and abundance of steelhead is based primarily on commercial and research vessel catch and their abundances in these catches, which are usually low throughout their extensive ocean range compared to other Pacific salmon (Myers, 2018). If exposed to surface explosions, steelhead would likely experience physiological and behavioral reactions to the brief (seconds to minutes) and infrequent activities based on the low probability of co-occurrence between testing and training activities and this species. Although individuals may be impacted, long-term consequences for populations would not be expected. Explosive stressors would not overlap with designated critical habitat for steelhead.

Pursuant to the ESA, the use of explosives during testing and training activities as described under Alternative 1 may affect but is not likely to adversely affect the ESA-listed Southern California Coast DPS of steelhead. The Navy has consulted with NMFS, as required by section 7(a)(2) of the ESA.

3.6.5.2.2 Energy

The only energy stressors that could potentially impact fishes are high-energy lasers, which are weapons designed to disable surface targets, rendering them immobile. The primary impact from high-energy lasers would be from the laser beam striking the fish at or near the water's surface during surface-to-surface and surface-to-air activities, which could result in injury or death. Under Alternative 1, there would be no changes to the HEL and HPM system parameters or testing and training activities as described and analyzed in the 2015 Final SNI Directed Energy Test Facilities Environmental Assessment (U.S. Department of the Navy, 2015) or the 2014 Final Point Mugu Sea Range Countermeasures Environmental Assessment (U.S. Department of the Navy, 2014) (see Section 2.1.3.2, Directed Energy Weapons Test).

Fish could be exposed to a laser only if the beam missed the target. Should the laser strike the sea surface, individual fish at or near the surface could be exposed. The potential for exposure to a high-energy laser beam decreases as the water depth increases. Most fish are unlikely to be exposed to laser activities because they primarily occur more than a few meters below the sea surface.

Under Alternative 1, fishes found in offshore locations that occur near the surface of the water column may pose a higher risk of being exposed to high-energy lasers. However, it is very unlikely that an individual would surface at the exact moment in the exact place that the laser hit the surface. Fishes are unlikely to be exposed to high-energy lasers based on (1) the relatively low number of events, (2) the very localized potential impact area of the laser beam, and (3) the temporary duration of potential impact (seconds). Therefore, potential impacts on fishes from the use of high-energy lasers under Alternative 1 would be less than significant.

The potential to impacts on an ESA-listed steelhead would be highly unlikely given their extremely low abundances throughout their extensive ocean range (Myers, 2018). In addition, physiological and behavioral reactions would be expected to be brief (seconds to minutes) and infrequent based on the low probability of co-occurrence between testing and training activities and this species. Although individuals may be impacted, long-term consequences for populations would not be expected. High-energy laser weapons tests also would not overlap with designated critical habitat for steelhead.

Under Alternative 1, pursuant to the ESA, use of high-energy lasers would have no effect on the ESA-listed Southern California Coast DPS of steelhead.

3.6.5.2.3 Physical Disturbance and Strike

This section analyzes the disturbance or strike potential to fish from military expended materials such munitions and expended materials other than munitions, such as expendable targets. While disturbance or strike from any of these objects as they sink through the water column is possible, it is not very likely for most expended materials because the objects generally sink through the water slowly and can be avoided by most, if not all, fishes. Therefore, the discussion of military expended materials strikes focuses on strikes at the surface or in the upper water column from fragments (of explosives) and projectiles because those items have a greater potential for a fish strike as they hit the water, before slowing down as they move through the water column.

Various types of projectiles could cause a temporary (seconds), localized impact when they strike the surface of the water. Direct munitions strikes from firing weapons are potential stressors to fishes. There is a remote possibility that an individual fish at or near the surface may be struck directly if it is at the point of impact at the time of non-explosive munitions delivery. Expended rounds may strike the water surface with sufficient force to cause injury or mortality. However, limited fish species swim right at, or near, the surface of the water (e.g., with the exception of pelagic sharks, herring, flyingfishes, jacks, tuna, mackerels, billfishes, ocean sunfishes, and other similar species).

Some individual fish at or near the surface may be struck directly by bombs, missiles, and rockets if they are at the point of impact at the time of non-explosive munitions delivery. However, most missiles hit their target or are disabled before hitting the water. Thus, most of these missiles hit the water as fragments, which quickly dissipates their kinetic energy within a short distance of the surface. A limited number of fishes swim right at, or near, the surface of the water, as described for small-, medium-, and large-caliber projectiles.

Fish occupying the impact area would be susceptible to potential impacts, either at the water surface (e.g., pelagic sharks, flyingfishes, jacks, tunas, mackerels, billfishes, and ocean sunfishes) or as military expended material falls through the water column and settles to the bottom (e.g., flatfishes, skates, and other benthic fishes). Furthermore, most of the projectiles fired during testing and training activities are fired at targets, and most projectiles hit those targets, so only a very small portion of those would hit the water with their maximum velocity and force. Of that small portion, a small number of fish at or near the surface (pelagic fishes) or near the bottom (benthic fishes) may be directly impacted if they are in the target area and near the expended item that hits the water surface (or bottom). The expected reaction of fishes exposed to military expended materials would be to immediately leave the area where stressor is occurring, thereby reducing the probability of a fish strike after the initial expended materials hit the water surface. When a disturbance of this type concludes, the area would be repopulated and the fish stock would rebound, with inconsequential impacts on the resource (Lundquist et al., 2010).

Under Alternative 1, the amount of military expended materials associated with testing and training activities that would be a potential physical disturbance and strike risk to marine fishes would increase compared to current environmental baseline conditions (see Table 3.0-12). However, impacts of military expended material strikes on fishes, including ESA-listed steelhead, would be inconsequential due to (1) the limited number of species found directly at the surface where military expended material strikes could occur, (2) the rare chance that a fish might be directly struck at the surface by military expended materials, and, (3) the ability of most fishes to detect and avoid an object falling through the water below the surface. The potential impacts of military expended material strikes would be short-term (seconds) and localized disturbances of the water surface (and seafloor areas within sinking exercise boxes) and are not expected to yield any behavioral changes or lasting effects on the survival, growth, recruitment, or reproduction at the population level. Therefore, potential impacts on fishes from a physical disturbance or strike by military expended material under Alternative 1 would be less than significant.

Physical disturbance and strike stressors would not overlap with designated critical habitat for steelhead, and as discussed above, steelhead are likely sparsely distributed within the Study Area.

Pursuant to the ESA, the use of military expended materials during testing and training activities as described under Alternative 1 may affect but is not likely to adversely affect the ESA-listed Southern California Coast DPS of steelhead. The Navy has consulted with NMFS, as required by section 7(a)(2) of the ESA.

3.6.5.2.4 Ingestion

This section analyzes the potential ingestion impacts of the various types of munitions and military expended materials other than munitions used by the Navy during testing and training activities within the Study Area. Ingestion of expended materials by fishes could occur at or just below the surface, in the water column, or at the seafloor depending on the size and buoyancy of the expended object and the feeding behavior of the fish. Floating material is more likely to be eaten by fishes that feed at or near the water surface (e.g., ocean sunfish, basking sharks, or flyingfishes), while materials that sink to the seafloor present a higher risk to bottom-feeding fishes (e.g., rockfishes, skates, and flatfishes).

It is reasonable to assume that any item of a size that can be swallowed by a fish could be eaten at some time; this analysis focuses on ingestion of materials in two locations: (1) at the surface or water column, and (2) at the seafloor. The potential for fish to encounter and ingest expended materials is evaluated with respect to their feeding group and geographic range, which influence the probability that they would eat military expended materials.

The Navy expends various types of materials during testing and training in the Study Area that could become ingestion stressors, including non-explosive (inert) practice munitions, fragments from explosives, and fragments from targets. Metal items eaten by fish are generally small (such as fishhooks, bottle caps, and metal springs), suggesting that small- and medium-caliber projectiles are more likely to be ingested. Both physical and toxicological impacts could occur as a result of consuming metal or plastic materials (Dantas et al., 2012; Davison & Asch, 2011; Possatto et al., 2011). Ingestion of plastics has been shown to increase hazardous chemicals in fish leading to liver toxicity of fishes (Rochman et al., 2013). Items of concern are those of ingestible size that either drift at or just below the surface (or in the water column) for a time or sink immediately to the seafloor. It is possible that expended small-caliber projectiles on the seafloor could be colonized by seafloor organisms and mistaken for prey or that expended small-caliber projectiles could be accidentally or intentionally eaten during foraging. Over time, the metal may corrode or become covered by sediment in some habitats, reducing the likelihood of a fish encountering the small caliber, non-explosive practice munitions.

The likelihood that expended items would cause a potential impact on a given fish species depends on the size and feeding habits of the fish and the rate at which the fish encounters the item and the composition of the item. For many small fish species (e.g., anchovy, sardines), military expended materials are often too large to be ingested, even though small pieces could sometimes be nibbled off by small fishes.

Potential impacts of ingestion on some adult fishes are different than for other life stages (eggs, larvae, and juveniles) because early life stages for some species are too small to ingest any military expended materials except for chaff, which has been shown to have limited effects on fishes in the concentration levels that it is released at (Arfsten et al., 2002; U.S. Department of the Air Force, 1997; U.S. Department of the Navy, 1999). Therefore, with the exception of later stage larvae and juveniles that could ingest microplastics, no potential ingestion impacts on early life stages are expected.

Under Alternative 1, the amount of military expended materials associated with testing and training activities of ingestible size for marine fishes would increase compared to current environmental baseline conditions (see Table 3.0-12). Ingestion of munitions-related materials or the other military expended materials could result in sublethal or lethal impacts on fishes. However, the likelihood of ingestion is low based on the dispersed nature of the materials and the limited exposure of those items at the surface/water column or seafloor where certain fishes could be at risk of ingesting those items. Furthermore, a fish might taste an item and then expel it instead of swallowing it (Felix et al., 1995), in the same manner that fish would temporarily take a lure into its mouth, then spit it out. Based on these factors, the number of fish potentially impacted by ingestion of military expended materials would be low and population-level impacts are not likely to occur. Therefore, potential impacts from ingestion of military expended material to fishes under Alternative 1 would be less than significant. While munitions use could overlap with ESA-listed steelhead, the likelihood of ingestion would be extremely low given the low abundance of this ESA species in the Study Area and the dispersed nature of the activity. Ingestion stressors would not overlap with designated critical habitat for steelhead. Therefore, potential impacts on fishes from ingestion of military expended material under Alternative 1 would be less than significant.

While munitions use could overlap with ESA-listed steelhead, the likelihood of ingestion would be extremely low given the low abundance of this ESA species in the Study Area and the dispersed nature of the activity. Ingestion stressors would not overlap with designated critical habitat for steelhead.

Pursuant to the ESA, the use of military expended materials during testing and training activities as described under Alternative 1 may affect but is not likely to adversely affect the ESA-listed Southern California Coast DPS of steelhead. The Navy has consulted with NMFS, as required by section 7(a)(2) of the ESA.

3.6.5.3 Alternative 2

3.6.5.3.1 Explosives

Under Alternative 2, marine fishes would be exposed to surface explosions and associated underwater impulsive sounds from high-explosive munitions such as bombs and missiles during air-to-surface and surface-to-surface activities (see Table 3.0-7). Explosives would be used throughout the Study Area. A discussion of explosives, including explosive source classes, is provided in Section 3.0.5.6 (Explosive Stressors). The number of explosives used under Alternative 2 would decrease compared to Alternative 1, but increase slightly from current environmental baseline conditions (see Table 3.0-7).

As described above for Alternative 1, sound and energy from explosions could result in mortality and injury, on average, for hundreds to even thousands of meters from some of the largest explosions (larger bins). Exposure to explosions could also result in hearing loss in nearby fishes. Generally, explosives that belong to larger bins (with large net explosive weights) produce longer ranges within each effect category. However, some ranges vary depending upon a number of other factors (e.g., number of explosions in a single activity). Fishes without a swim bladder, adult fishes, and larger species would generally be less susceptible to injury and mortality from sound and energy associated with explosive activities than small, juvenile, or larval fishes. Fishes that experience hearing loss could miss opportunities to detect predators or prey, or show a reduction in interspecific communication.

Because explosions from Navy testing and training activities under Alternative 2 would be concentrated at the water's surface, only pelagic species and more surface-oriented species would be impacted by explosions. Overall, the number of fish species affected by explosions would be low compared to the total number of fish species in Study Area. Therefore, potential impacts from explosions to fishes under Alternative 2 would be less than significant.

Impacts on ESA-listed steelhead would be similar to impacts on fishes in general. However, due to the short-term, infrequent and localized nature of these activities, and the fact that steelhead, if they occur in the offshore portions of the Study Area, are unlikely to be exposed to at or near surface explosions, especially since their population numbers in Southern California are so low (Boughton et al., 2006). This is because information on the ocean distribution and abundance of steelhead is based primarily on commercial and research vessel catch and their abundances in these catches is usually low throughout their extensive ocean range compared to other Pacific salmon (Myers, 2018). In addition, physiological and behavioral reactions would be expected to be brief (seconds to minutes) and infrequent based on the low probability of co-occurrence between testing and training activities and this species. Although individuals may be impacted, long-term consequences for populations would not be expected. Explosive stressors would not overlap with designated critical habitat for steelhead.

Pursuant to the ESA, the use of explosives during testing and training activities as described under Alternative 2 may affect but is not likely to adversely affect the ESA-listed Southern California Coast DPS of steelhead.

3.6.5.3.2 Energy

Under Alternative 2, the number of high-energy laser weapons testing events would be the same compared to both Alternative 1 and current environmental baseline conditions. As described above for Alternative 1, fishes found in offshore locations that occur near the surface of the water column may pose a higher risk of being exposed to high-energy lasers. However, it is very unlikely that an individual would surface at the exact moment in the exact place that the laser hit the surface. Fishes are unlikely to be exposed to high-energy lasers based on (1) the relatively low number of events, (2) the very localized potential impact area of the laser beam, and (3) the temporary duration of potential impact (seconds). Therefore, potential impacts on fishes from the use of high-energy lasers under Alternative 2 would be less than significant. High-energy laser weapons tests also would not overlap with designated critical habitat for steelhead.

Pursuant to the ESA, the use of high-energy lasers during testing and training activities as described under Alternative 2 would have no effect on the ESA-listed Southern California Coast DPS of steelhead.

3.6.5.3.3 Physical Disturbance and Strike

As described above under Alternative 1, various types of projectiles could cause a temporary (seconds), localized impact when they strike the surface of the water. Under Alternative 2, proposed Navy activities in the Study Area that would expend military material as a potential strike hazard to fishes.

Under Alternative 2, the amount of military expended material would decrease compared to Alternative 1 and would increase slightly compared to current environmental baseline conditions (see Table 3.0-12). There is a remote possibility that an individual fish at or near the surface may be struck directly if it is at the point of impact at the time of non-explosive munitions delivery. Expended rounds may strike the water surface with sufficient force to cause injury or mortality. However, limited fish species swim right at, or near, the surface of the water (e.g., with the exception of pelagic sharks, herring, flyingfishes, jacks, tuna, mackerels, billfishes, ocean sunfishes, and other similar species).

Under Alternative 2, potential impacts of military expended material strikes on fishes, including ESA-listed steelhead, would be inconsequential due to (1) the limited number of species found directly at the surface where military expended material strikes could occur, (2) the rare chance that a fish might be directly struck at the surface by military expended materials, and, (3) the ability of most fishes to detect and avoid an object falling through the water below the surface. The potential impacts of military expended material strikes would be short-term (seconds) and localized disturbances of the water surface (and seafloor areas within sinking exercise boxes) and are not expected to yield any behavioral changes or lasting effects on the survival, growth, recruitment, or reproduction at the population level. Therefore, potential impacts on fishes from a physical disturbance or strike by military expended material under Alternative 1 would be less than significant.

Under Alternative 2, physical disturbance and strike stressors would not overlap with designated critical habitat for steelhead.

Pursuant to the ESA, the use of military expended material during testing and training activities as described under Alternative 2 may affect but is not likely to adversely affect the ESA-listed Southern California Coast DPS of steelhead.

3.6.5.3.4 Ingestion

As described above for Alternative 1, the Navy expends materials during testing and training in the Study Area that could be ingested by marine fishes, including non-explosive (inert) munitions, fragments from explosives, fragments from targets, and ordnance. Metal items eaten by fish are generally small (such as fishhooks, bottle caps, and metal springs), suggesting that small- and medium-caliber projectiles are more likely to be ingested. Both physical and toxicological impacts could occur as a result of consuming metal or plastic materials (Dantas et al., 2012; Davison & Asch, 2011; Possatto et al., 2011). Ingestion of plastics has been shown to increase hazardous chemicals in fish leading to liver toxicity of fishes (Rochman et al., 2013). Items of concern are those of ingestible size that either drift at or just below the surface (or in the water column) for a time or sink immediately to the seafloor. It is possible that expended small-caliber projectiles on the seafloor could be colonized by seafloor organisms and mistaken for prey or that expended small-caliber projectiles could be accidentally or intentionally eaten during foraging. Over time, the metal may corrode or become covered by sediment in some habitats, reducing the likelihood of a fish encountering the small caliber, non-explosive practice munitions.

As described above for Alternative 1, the likelihood that expended items would cause a potential impact on a given fish species depends on the size and feeding habits of the fish and the rate at which the fish encounters the item and the composition of the item. For many small fish species (e.g., anchovy, sardines, etc.), military expended materials are often too large to be ingested, even though small pieces could sometimes be nibbled off by small fishes.

Under Alternative 2, military expended materials associated with testing and training activities of ingestible size that could potentially be ingested by marine fishes would increase compared to current environmental baseline conditions (see Table 3.0-12). Ingestion of military expended materials or the other military expended materials could result in sublethal or lethal impacts on fishes. However, the likelihood of ingestion is low based on the dispersed nature of the materials and the limited exposure of those items at the surface/water column or seafloor where certain fishes could be at risk of ingesting those items. Furthermore, a fish might taste an item and then expel it instead of swallowing it (Felix et al., 1995), in the same manner that fish would temporarily take a lure into its mouth, then spit it out. Based on these factors, the number of fish potentially impacted by ingestion of military expended materials would be low, and population-level impacts are not likely to occur. Therefore, potential impacts from ingestion of military expended material to fishes under Alternative 2 would be less than significant.

While munitions use could overlap with ESA-listed steelhead, the likelihood of ingestion would be extremely low given the low abundance of this ESA species in the Study Area and the dispersed nature of the activity. Ingestion stressors would not overlap with designated critical habitat for steelhead.

Pursuant to the ESA, the use of military expended material during testing and training activities as described under Alternative 2 may affect but is not likely to adversely affect the ESA-listed Southern California Coast DPS of steelhead.

3.6.5.4 Indirect Effects

This section analyzes potential impacts on fishes exposed to stressors indirectly through impacts on prey availability and habitat (e.g., sediment or water quality, and physical disturbance). For the purposes of this analysis, indirect impacts on fishes via sediment or water that do not require trophic transfer (e.g., bioaccumulation) in order to be observed are considered here. It is important to note that the term "indirect" does not imply reduced severity of environmental consequences, but instead describes how the impact may occur in an organism or its ecosystem.

Stressors from Navy testing and training activities could pose secondary or indirect impacts on fishes via habitat (e.g., sediment, and water quality) and prey availability. These stressors include (1) explosives and explosion byproducts; (2) metals; (3) chemicals; and (4) other military expended materials such as targets, chaff, and plastics.

Explosions

Secondary impacts on fishes resulting from explosions at the surface would be associated with changes to habitat structure and effects on prey species. Plankton and zooplankton that are eaten by fishes in the water column may also be negatively impacted by explosions near the surface. However, the spatial area impacted by proposed testing and training activities would be relatively small compared to the available habitat in the Study Area, and there would still be vast expanses of habitat adjacent to the areas of habitat impact that would remain undisturbed.

Explosion By-Products

Indirect effects of explosion by-products to fishes in the water column is possible. Degradation products of royal demolition explosive are not toxic to marine organisms at realistic exposure levels (Rosen & Lotufo, 2010). Trinitrotoluene (TNT) and its degradation products impact developmental processes in fishes and are acutely toxic to adults at concentrations similar to real-world exposures (Halpern et al., 2008b; Rosen & Lotufo, 2010). Relatively low solubility of most explosives and their degradation products means that concentrations of these contaminants in the marine environment are relatively low and readily diluted. Furthermore, while explosives and their degradation products were detectable in marine sediment approximately 0.15–0.3 m away from degrading munitions, the concentrations of these compounds were not statistically distinguishable from background beyond 1–2 m from the degrading munitions (Section 3.2, Sediments and Water Quality). Taken together, it is likely that various life stages of fishes could be impacted by the indirect impacts of degrading explosives within a very small radius of the explosive (0.3–2 m).

Metals

Certain metals and metal-containing compounds at concentrations above background levels (e.g., cadmium, chromium, lead, mercury, zinc, copper, manganese, and many others) can be toxic to fishes (Wang & Rainbow, 2008). Metals are introduced into seawater (and sediments) as a result of testing and training activities involving targets, munitions, and other military expended materials. Some metals bioaccumulate, and physiological impacts begin to occur only after several trophic transfers concentrate the toxic metals (U.S. Department of the Navy, 2012). Indirect effects of metals on fish via sediment and water involve concentrations several orders of magnitude lower than concentrations achieved via bioaccumulation. Fishes may be exposed by contact with the metal, contact with contaminants in the sediment or water, and ingestion of contaminated sediments. Concentrations of metals in seawater are orders of magnitude lower than concentrations in marine sediments. It is extremely unlikely that fishes would be indirectly impacted by toxic metals via the water.

Chemicals

Several Navy testing and training activities introduce potentially harmful chemicals into the marine environment, principally flares and propellants for rockets and missiles. However, properly functioning flares, missiles, and rockets combust most of their propellants, leaving benign or readily diluted soluble combustion byproducts (e.g., hydrogen cyanide). Operational failures allow propellants and their degradation products to be released into the marine environment.

The greatest risk to fishes from flares, missiles, and rocket propellants is perchlorate, which is highly soluble in water, persistent, and impacts metabolic processes in many plants and animals. Fishes may be exposed by contact with contaminated water or ingestion of re-suspended contaminated sediments. Since perchlorate is highly soluble, it does not readily adsorb to sediments. Therefore, missile and rocket fuels pose no risk of indirect impact on fishes via sediment. In contrast, the principal toxic components of torpedo fuel, propylene glycol dinitrate and nitrodiphenylamine, adsorb to sediments, have relatively low toxicity, and are readily degraded by biological processes. It is conceivable that various life stages of fishes could be indirectly impacted by propellants via sediment in the immediate vicinity of the object (e.g., within a few inches), but these potential impacts would diminish rapidly as the propellant degrades.

3.6.5.4.1 Impacts on Habitat

The proposed testing and training activities could result in localized and temporary changes to the benthic community (see Section 3.3, Marine Habitats) during activities that impact fish habitat. Hard bottom is important habitat for many different species of fish, including those fishes managed by various fishery management plans. Fish habitat could become degraded during activities that would strike the seafloor or introduce military expended materials, bombs, projectiles, missiles, rockets, or fragments to the seafloor. The spatial area of habitat impacted by these activities would be relatively small compared to the available habitat in the Study Area. However, there would still be vast expanses of habitat adjacent to the areas of habitat impact that would remain undisturbed. In addition, the majority of the physical and biological features required by steelhead are applicable to freshwater and estuaries (i.e., spawning sites, rearing sites, and migration corridors) and are outside the Study Area.

Pursuant to the ESA, indirect effects, such as impacts on habitat from testing and training activities, as described above, may affect but would not be likely to adversely affect steelhead critical habitat, including the ESA-listed Southern California Coast DPS of steelhead.

3.6.5.4.2 Impacts on Prey Availability

Impacts on fish prey availability resulting from explosives, explosives byproducts, metals, and chemicals would differ depending upon the type of prey species in the area, but would likely be negligible overall and have no population-level impacts on fishes. During or following activities that impact the water column, plankton and zooplankton that are eaten by fishes may also be negatively impacted by these same expended materials; for example, some species of zooplankton that occur in the Pacific, such as Pacific oyster (*Crassostrea gigas*) larvae, have been found feeding on microplastics (Cole & Galloway, 2015).

The abundances of fish and invertebrate prey species near the detonation point could be diminished for a short period of time before being repopulated by animals from adjacent waters. The sound from underwater explosions might induce startle reactions and temporary dispersal of schooling fishes, potentially increasing visibility to predators if they are within close proximity (Kastelein et al., 2008). Alternatively, any prey species that would be directly injured or killed by the blast could draw in scavengers from the surrounding waters that would feed on those organisms, and in turn could be susceptible to becoming directly injured or killed by subsequent explosions. Any of these scenarios would be temporary, only occurring during activities involving explosives, and no lasting impact on prey availability or the food web would be expected. Indirect impacts of surface detonations would not result in a decrease in the quantity or quality of fish populations in the Study Area.

Pursuant to the ESA, indirect effects, such as impacts on prey availability from testing and training activities, as described above, may affect but are not likely to adversely affect steelhead critical habitat, including the ESA-listed Southern California Coast DPS of steelhead.

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