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Overseas Environmental Impact Statement
Point Mugu Sea Range
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3.5 Marine Invertebrates

3.5.1 Introduction

This section analyzes the potential impacts of Navy testing and training activities on marine invertebrates found in the Point Mugu Sea Range (PMSR) Study Area. Section 3.5.4.2 (Marine Invertebrates 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 3.5.5 (Environmental Consequences).

For this Environmental Impact Statement/Overseas Environmental Impact Statement, marine invertebrates are evaluated as major taxonomic groups characterized by distribution, morphology (body type), or behavior relevant to the stressor being evaluated. Activities are evaluated for their potential effects on the marine invertebrates in the Study Area.

The affected environment provides the context for evaluating the effects of the Navy testing and training activities on invertebrates. Because invertebrates occur in all habitats, activities that interact with the water column or the bottom could potentially impact many species and individuals, including microscopic zooplankton (e.g., invertebrate larvae, copepods, protozoans) that drift with currents, larger invertebrates living in the water column (e.g., jellyfish, shrimp, squid), and benthic invertebrates that live on or in the seafloor (e.g., clams, sea fans, crabs, worms). Because many benthic animals have limited mobility compared to pelagic species, activities that contact the bottom generally have a greater potential for impact. Activities that occur in the water column generally have a lesser potential for impact due to dilution and dispersion of some stressors (e.g., chemical contaminants), potential drifting of small invertebrates out of an impact area, and the relatively greater mobility of open water invertebrates large enough to actively leave an impact area.

Endangered Species Act (ESA)-listed species of marine invertebrates that occur in the Study Area are presented separately under the appropriate taxonomic group. The National Marine Fisheries Service (NMFS) maintains a website that provides additional information on the biology, life history, species distribution (including maps), and conservation of marine invertebrates.

3.5.2 Region of Influence

The region of influence (ROI) for marine invertebrates consists of the PMSR, Point Mugu (Mugu Lagoon and sandy beaches/nearshore environment), and the intertidal and nearshore subtidal areas surrounding San Nicolas Island. While Navy support boats and surface targets transit in and out of Port Hueneme to the PMSR, marine invertebrates within the port are not addressed further because vessel transits would not affect marine invertebrates within Port Hueneme.

3.5.3 Approach to Analysis

The factors used to assess significance of impacts on marine invertebrates include the extent or degree to which implementation of an alternative would result in loss or degradation of sensitive marine habitats (e.g., lagoon, intertidal, and shallow subtidal) or loss or degradation of sensitive marine species. “Sensitive” habitats or species are those that are demonstrably rare, threatened, or endangered; are protected by federal or state statutes or regulations; or have recognized commercial, recreational, or scientific importance. The analysis of potential impacts on marine invertebrates from each alternative is presented in Section 3.5.5 (Environmental Consequences).

3.5.4 Affected Environment

This section provides brief summaries of habitat use, movement and behavior, sound sensing and production, and general threats that have the potential to affect natural communities of marine invertebrates within the Study Area. Common marine invertebrates and those species listed under the ESA are described in Section 3.5.4.2 (Marine Invertebrates in the Study Area).

3.5.4.1 General Background

Invertebrates, which are animals without backbones, are the most abundant life form on Earth, with marine invertebrates representing a large, diverse group with approximately 367,000 species described worldwide to date (World Register of Marine Species Editorial Board, 2015). However, it is estimated that most existing species have not yet been described (Mora et al., 2011). The total number of invertebrate species that occur in the Study Area is unknown but is likely to be many thousands. The results of a research effort to estimate the number of marine invertebrate species in various areas identified over 8,000 species in the California Current large marine ecosystem (Fautin et al., 2010). Invertebrate species vary in their use of abiotic habitats, and some populations are threatened by human activities and other natural changes, especially endangered species.

Marine invertebrates are important ecologically and economically, providing an important source of food, essential ecosystem services (coastal protection, nutrient recycling, food for other animals, habitat formation), and income from tourism and commercial fisheries (Spalding et al., 2001). The health and abundance of marine invertebrates are vital to the marine ecosystem and the sustainability of the world's fisheries (Pauly et al., 2002). Economically important invertebrate groups that are fished, commercially and recreationally, for food in the United States include crustaceans (e.g., shrimps, lobsters, and crabs), bivalves (e.g., scallops, clams, and oysters), echinoderms (e.g., sea urchins and sea cucumbers), and cephalopods (e.g., squids and octopuses) (Chuenpagdee et al., 2003; Food and Agriculture Organization of the United Nations, 2005; Pauly et al., 2002). Marine invertebrates or the structures they form (e.g., shells and cup coral colonies) are harvested for many purposes, including jewelry, curios, and the aquarium trade. In addition, some marine invertebrates are sources of chemical compounds with potential medical applications. Natural products have been isolated from a variety of marine invertebrates and have shown a wide range of therapeutic properties, including anti-microbial, antioxidant, anti-hypertensive, anticoagulant, anticancer, anti-inflammatory, wound healing and immune modulation, and other medicinal effects (De Zoysa, 2012).

3.5.4.1.1 Habitat Use

Marine invertebrates live in all of the world's oceans, from warm shallow waters to cold deep waters. They inhabit the bottom and all depths of the water column in large marine ecosystems (California Current) and the open-ocean areas that occur in the Study Area (Brusca & Brusca, 2003). Many species that occur in the water column are either microscopic or not easily observed with the unaided eye (e.g., protozoans, copepods, and the larvae of larger invertebrate species). Many invertebrates migrate to deeper waters during the day, presumably to decrease predation risk. However, some invertebrates, such as some jellyfish and squid species, may occur in various portions of the water column, including near the surface, at any time of day. In addition, under certain oceanographic conditions, other types of invertebrates such as pelagic crabs (*Pleuroncodes planipes*) and by-the-wind sailors (*Velella velella*) may occur near the surface during the day. Deep-sea corals in Southern California are diverse and abundant, with a total of 15 coral genera recently being identified using remotely operated vehicles (Salgado et al., 2018). The Study Area extends from the bottom up to the mean high tide line (often termed mean high water in literature). The description of habitat use in this section pertains to common marine invertebrates found in the different habitats. This section also identifies marine invertebrates that form persistent habitats, which are considered to be structures that do not quickly disintegrate or become incorporated into soft or intermediate substrate after the death of the organism. The principal habitat-forming invertebrates in the Study Area are shellfish species (e.g., oysters, mussels). In a strict sense, individual invertebrates with hard shells (e.g., molluscs), outer skeletons (e.g., crabs), tubes (e.g., annelid worms), or cavities (e.g., sponges) also may be habitat-forming, providing attachment surfaces or living spaces for other organisms. The abiotic (nonliving) components of all habitat types are addressed in Section 3.3 (Marine Habitats), and marine vegetation components are discussed in Section 3.4 (Marine Vegetation).

Marine invertebrate distribution in the Study Area is influenced by habitat (e.g., abiotic substrate, topography, biogenic [formed by living organisms] features), ocean currents, and physical and water chemistry factors such as temperature, salinity, and nutrient content (Levinton, 2009). Distribution is also influenced by distance from the equator (latitude) and distance from shore. In general, the number of marine invertebrate species (species richness) increases toward the equator (Cheung et al., 2005; Macpherson, 2002). Species richness and overall abundance are typically greater in coastal water habitats compared to the open ocean due to the increased availability of food and protection that coastal habitats provide (Levinton, 2009).

The diversity and abundance of Arthropoda (e.g., crabs, lobsters, and barnacles) and Mollusca (e.g., snails, clams, and squid) are highest on the bottom over the continental shelf due to high productivity and availability of complex habitats relative to typical soft bottom habitat of the deep ocean (Karleskint et al., 2006). Organisms occurring in the bathyal and abyssal zones of the ocean are generally small and have sparse populations (Nybakken, 1993). The deep ocean has a limited food supply for sedentary deposit or filter feeders. The only areas of the deep ocean known to be densely populated are hydrothermal vents and cold seeps (refer to Section 3.3, Marine Habitats, for additional information on these features).

Sandy coastal shores are dominated by species that are adapted to living in shifting substrates, many of which are highly mobile and can burrow. Common invertebrates of Southern California beaches include common sand crab (*Emerita analoga*) and a variety of isopods, amphipods, bivalves, snails, worms, and insects (Dugan et al., 2000; Dugan et al., 2015). Inland soft shores consist of mud flats and sand flats that occur in areas sheltered from strong currents and waves. Soft shore habitats may support a wide variety of invertebrate species including crabs, shrimp, clams, snails, and numerous species of worms. Invertebrates documented in tidal flats in Southern California include numerous taxa of worms, crustaceans, and molluscs (Talley et al., 2000; Thompson et al., 1993). California horn snail (*Cerithidea californica*) is the dominant invertebrate of mud flats.

Intermediate (e.g., cobble, gravel) and rocky shores provide habitat for a variety of marine invertebrates (e.g., sea anemones, barnacles, chitons, limpets, mussels, urchins, sea stars, sponges, tunicates, and various worms). Rocky intertidal invertebrates may be attached or free living/mobile, and use various feeding strategies (e.g., filter-feeders, herbivores, carnivores, scavengers). Many invertebrates occurring in rocky intertidal zones are preyed upon by fish, birds, and other invertebrates. The black abalone (*Haliotis cracherodii*) and white abalone (*Haliotis sorenseni*), which are listed as endangered species under the ESA, occur infrequently in Southern California rocky intertidal and subtidal habitats. Hard artificial structures such as pier pilings and seawalls can have a community of invertebrates that is similar to that of rocky habitats.

Vegetated habitats, such as eelgrass (*Zostera marina* and *Z. pacifica*) in embayments and protected soft bottom coastal areas, surfgrass on rocky intertidal and nearshore subtidal habitat, and kelp forests in nearshore subtidal habitats, support a wide variety of marine invertebrate species. Eelgrass provides important habitat for invertebrates in Southern California (Bernstein et al., 2011). Similar to kelps, seagrasses are foundation species that support high productivity and faunal diversity (Duffy et al., 2015). For example, more than 50 species of invertebrates have been documented in some surfgrass beds in Southern California (Stewart & Myers, 1980). Surfgrass also serves as the primary nursery habitat for the commercially important California spiny lobster (*Panuliris interruptus*). Several hundred species of invertebrates have been reported in giant kelp forests of California, in association with rocky substratum, kelp holdfasts, and as epiphytes on kelp blades (Foster & Schiel, 1985). Conspicuous or commonly observed invertebrates in kelp forests include cnidarians (sea anemones, gorgonian sea fans), sponges, arthropod crustaceans (e.g., crabs, California spiny lobster), molluscs (e.g., abalone, keyhole limpet, octopus, nudibranchs, sea hares), and echinoderms (e.g., sea cucumbers, sea stars, sea urchins).

Rocky reefs and other rocky habitats may occur in subtidal zones. Invertebrate species composition associated with rocky subtidal habitats may be influenced by depth, size, and structural complexity of the habitat. Hundreds of invertebrate species may occur in rocky habitats, which provide attachment sites for sessile (attached to the bottom) species such as barnacles, bryozoans, limpets, sea anemones, sea fans, sponges, and tunicates, among others. Other invertebrates move about or shelter in crevices, including crustaceans (e.g., crabs, lobsters), echinoderms (e.g., brittle stars, sea cucumbers, sea urchins, sea stars), and molluscs (e.g., snails, nudibranchs, sea hares, octopus).

Chemosynthetic communities may support a relatively high biomass of marine invertebrates. Instead of using photosynthesis driven by sunlight, chemosynthetic organisms derive energy from chemicals originating from the earth’s crust. The primary types of habitats supporting chemosynthetic communities are hydrothermal vents and cold seeps. Hydrothermal vents form when seawater permeates downward through the earth’s crust and upper mantle, becomes superheated, and removes minerals and chemicals from the crust. The heated fluid may then rise through fissures in the crust and reach cold ocean water at the seafloor, where metals and other minerals precipitate out to form mounds or chimneys. Communities of microbes, such as bacteria, may colonize these structures and use chemicals occurring in the fluid (primarily hydrogen sulfide or methane) to make energy. The microbes may then become the base of a food web that contains invertebrates such as crabs, clams, mussels, worms, snails, and shrimp (Ross et al., 2012; Woods Hole Oceanographic Institution, 2015). Cold seeps are similar to hydrothermal vents, but the fluid exiting the crust is cooler, typically moves at a slower rate, and may spread over a larger area. Methane hydrates (ice-like structures that contain methane) are associated with some chemosynthetic communities. Cold seeps are generally associated with hard substrate on offshore shelf breaks, submarine canyons, and seamounts; refer to Section 3.3 (Marine Habitats) for spatial information on the habitats typically occupied by chemosynthetic communities. Cold seeps have been found in association with multiple fault systems off Southern California, including the San Clemente (Bernardino & Smith, 2010; Torres et al., 2002), San Pedro (Paull et al., 2008), and San Diego Trough faults (Grupe et al., 2015).

3.5.4.1.2 Movement and Behavior

Marine benthic and epibenthic (animals that live on the surface of the substrate) invertebrates may be sessile, sedentary (limited mobility), or highly mobile (but typically slower than large vertebrates). Several beach invertebrates, including sand crabs (*Emerita* spp.), Pismo clams (*Tivela stultorum*), and polychaete worms (class Polychaeta) recruit to beaches during spring and summer and seasonally move to shallow nearshore waters during late fall and winter. Some subtidal epibenthic invertebrates undergo seasonal onshore-offshore migrations associated with reproduction (e.g., California spiny lobster).

Pelagic marine invertebrates include plankton (organisms that do not swim or generally cannot swim faster than water currents) and nekton (active swimmers that can generally swim faster than water currents). Planktonic animals commonly undergo daily migrations to surface waters at dusk and return to deeper waters at dawn. This includes small, microscopic zooplankton and larvae, larger crustaceans (e.g., small shrimp), and jellyfish. Planktonic organisms vary in their swimming abilities, ranging from weak (e.g., larvae) to substantial (e.g., box jellyfish). Nekton such as prawns, shrimps, and squid have relatively strong swimming ability, although they are typically slower than most vertebrate animals.

3.5.4.1.3 Sound Sensing and Production

In general, organisms may detect sound by sensing either the particle motion or pressure component of sound, or both. Aquatic invertebrates probably do not detect pressure since many are generally the same density as water and few, if any, have air cavities that would respond to pressure (Budelmann, 1992b; Popper et al., 2001). Marine invertebrates, such as cephalopods and crustaceans, are species that are sensitive to water particle movements associated with sound or vibration and may perceive sound via either external sensory hairs or internal statocysts (Hu et al., 2009; Kaifu et al., 2008; Montgomery et al., 2006; Normandeau Associates, 2012; Popper et al., 2001). Because any acoustic sensory capabilities, if present, are apparently limited to detecting the local particle motion component of sound (Edmonds et al., 2016), and because water particle motion near a sound source falls off rapidly with distance, aquatic invertebrates are probably limited to detecting nearby sound sources rather than sound caused by pressure waves from distant sources.

In addition to hair cells and statocysts that allow some marine invertebrates to detect water particle motion, some species also have sensory organs called chordotonal organs that can detect substrate vibrations. Chordotonal organs are typically attached to connective tissue of flexible appendages such as antennae and legs (Edmonds et al., 2016). The structures are connected to the central nervous system and can detect some movements or vibrations that are transmitted through substrate.

Although many types of aquatic invertebrates produce sound and at least some species have the ability to detect low-frequency particle motion, little is known about the use of sound or whether all sound production is purposeful or merely incidental in some cases (Hawkins et al., 2015; Normandeau Associates, 2012). Some invertebrates have structures that appear to be designed specifically for sound production, and the results of various studies (summarized in the following paragraphs) indicate that sound is used for communication or other behaviors in some species. For example, it has been suggested by numerous researchers that the larvae of some marine species (e.g., crustaceans and molluscs) use sound cues for directional orientation (Budelmann, 1992a, 1992b; Montgomery et al., 2006; Popper et al., 2001).

Aquatic invertebrates may produce and use sound in territorial behavior, in the detection or deterrence of predators, and in reproduction (Popper et al., 2001). Some crustaceans produce sound by rubbing or closing hard body parts together (Au & Banks, 1998; Heberholz & Schmitz, 2001; Latha et al., 2005; Patek & Caldwell, 2006). The snapping shrimp chorus makes up a significant portion of the ambient noise in many locations (Au & Banks, 1998; Cato & Bell, 1992; Heberholz & Schmitz, 2001). Some crustaceans, such as the American lobster (*Homarus americanus*) and California mantis shrimp (*Hemisquilla californiensis*), may also produce sound by vibrating the carapace (Henninger & Watson, 2005; Patek & Caldwell, 2006). Spiny lobsters typically produce low-frequency rasps by moving a structure at the base of the antennae over a rigid file (Buscaino et al., 2011). Other crustaceans make low-frequency rasping or rumbling noises, perhaps used in defense or territorial display (Patek & Caldwell, 2006; Patek et al., 2009), or perhaps used incidental to a visual display.

3.5.4.1.4 General Threats

General threats to marine invertebrates include overexploitation and destructive fishing practices (Halpern et al., 2008; Jackson et al., 2001; Kaiser et al., 2002; Miloslavich et al., 2011; Pandolfi et al., 2003), habitat degradation resulting from pollution and coastal development (Cortes & Risk, 1985; Downs et al., 2009; Mearns et al., 2011), disease (Porter et al., 2001), invasive species (Bryant et al., 1998; Galloway et al., 2009; Wilkinson, 2002) (which may be introduced as a result of growth on vessel hulls or bilge water discharge), oil spills (Yender et al., 2010), global climate change and ocean acidification (Hughes et al., 2003), and possibly human-generated noise (Brainard et al., 2011; Vermeij et al., 2010). A relatively new threat to marine invertebrates is bioprospecting, which is the collection of organisms in pursuit of new compounds for development of pharmaceutical products (Radjasa et al., 2011). Threats related to water quality, marine debris, and climate change are further described in the subsections below.

3.5.4.1.4.1 Water Quality

Invertebrates may be affected by changes in water quality resulting from pollution, turbidity and increased particle deposition that may occur as a result of sediment disturbance, and waste discharge. As described in Section 3.2 (Sediments and Water Quality), stormwater runoff and point source discharges associated with coastal development may introduce pollutants into bays and other nearshore coastal areas. The pollutants may degrade sediment and water quality, which in turn can impact marine invertebrate communities. For example, erosion due to storm runoff may cause changes in the frequency or magnitude of sedimentation in areas in proximity to ocean outfalls, estuarine inlets, and major river discharges.

Ship discharges may affect water quality and invertebrates associated with the impacted water. Discharged materials include sewage, bilge water, graywater, ballast water, and solid waste (e.g., food and garbage). Discharges may originate from military, commercial, and recreational vessels. Under provisions of the Clean Water Act, the United States (U.S.) Environmental Protection Agency and the U.S. Department of Defense have developed Uniform National Discharge Standards to address discharges from U.S. military vessels. Refer to Section 3.2.3.2 (Federal Standards and Guidelines) for more information on water quality, including Uniform National Discharge Standards.

Marine invertebrates can be impacted by exposure to oil due to runoff from land, natural seepage, or accidental spills from offshore drilling/extraction or tankers (White et al., 2012). Reproductive and early life stages are especially sensitive to oil exposure. Factors such as oil type, quantity, exposure time, and season can affect the toxicity level.

3.5.4.1.4.2 Climate Change

The primary concerns of climate change in the context of impacts on marine invertebrates include increased water temperature, ocean acidification, increased frequency or intensity of cyclonic storm events, and sea level rise. Changing water temperatures can lead to potential physiological effects and changes in the distribution of some invertebrates. Northern and southern shifts in the geographic center of abundance of some benthic invertebrates along the U.S. Atlantic coast have occurred over the last 20 years, presumably in response to increased water temperature (Hale et al., 2017).

Ocean acidification has the potential to reduce calcification and growth rates in species with calcium carbonate skeletons, including shellfish (e.g., clams, oysters), sponges (Clark & Gobler, 2016; Cohen et al., 2009), and crustose coralline algae that contain calcite in their cell walls (Roleda et al., 2015), as well as affect weakly calcified taxa such as lobsters and sea cucumbers (Small et al., 2016; Verkaik et al., 2016).

In addition to physical effects, increased acidity may result in behavioral changes in some species. For example, acidification of porewater was found to affect burrowing behavior and juvenile dispersal patterns of the soft-shell clam (*Mya arenaria*) (Clements et al., 2016), and increased acidity caused a reduction in the loudness and number of snaps in the snapping shrimp *Alpheus novaezelandiae* (Rossi et al., 2016). Gelatinous invertebrates such as jellyfish generally seem to be tolerant of increased water acidity (Treible et al., 2018).

Although the potential effects that climate change could have on future storm activity is uncertain, numerous researchers suggest that rising temperatures could result in little change to the overall number of storms; however, storm intensity could increase (Voiland, 2013).

Sea level rise could affect invertebrates by modifying or eliminating habitat, particularly estuarine and intertidal habitats bordering steep and artificially hardened shorelines (Fujii, 2012). It is possible that intertidal invertebrates would colonize newly submerged areas over time if suitable habitat is present. Additional concerns include the potential for changes in ocean circulation patterns that affect the planktonic food supply of filter- and suspension-feeding invertebrates (Etnoyer, 2010). An increase in the future incidence of diseases in marine organisms is also theorized (Harvell et al., 2002).

3.5.4.1.4.3 Marine Debris

Marine debris (especially plastics) is a threat to many marine ecosystems, particularly in coastal waters adjacent to urban development. Microplastics (generally considered to be particles less than 5 millimeters in size), which may consist of degraded fragments of larger plastic items or intentionally manufactured items (e.g., abrasive plastic beads found in some personal care products or used in blast-cleaning), are of concern because of their durability and potential to enter marine food webs (Setala et al., 2016). Field and laboratory investigations have documented ingestion of microplastics by marine invertebrates including bivalve molluscs; crustacean arthropods such as lobsters, shore crabs, and amphipods; annelid lugworms; and zooplankton (Browne et al., 2013; Setala et al., 2014; Von Moos et al., 2012; Watts et al., 2014). While animals with different feeding modes have been found to ingest microplastics, laboratory studies suggest that filter-feeding and deposit feeding benthic invertebrates are at highest risk (Setala et al., 2016). Refer to Section 3.2 (Sediments and Water Quality) for a more detailed discussion of marine debris and the associated effects on water quality.

Recent studies in the Southern California Bight found that marine debris (primarily plastic) occurred in about one-third of seafloor areas surveyed (Moore et al., 2016). Microplastic particles were more prevalent in shallow nearshore areas (ports, marinas, bays, and estuaries) than in offshore areas. In addition, Moore et al. (2016) found the extent of seafloor macro-debris has nearly doubled from 1994 to 2013, and the extent of plastic has increased threefold. Another study of marine debris along the U.S. West Coast characterized the composition and abundance of manmade marine debris at 1,347 randomly selected stations during groundfish bottom trawl surveys that took place in 2007 and 2008 (Keller et al., 2010) and found that anthropogenic marine debris on the continental shelf and upper slope of the U.S. West Coast (Washington to Southern California) was widespread throughout the area investigated.

3.5.4.2 Marine Invertebrates in the Study Area

Marine invertebrates are classified within major taxonomic groups, generally referred to as a phylum. Major invertebrate phyla—those with greater than 1,000 species (Roskov et al., 2015; World Register of Marine Species Editorial Board, 2015)—and the general zones they inhabit in the Study Area are listed in Table 3.5-1. Vertical distribution information is generally shown for adults; the larval stages of most of the species occur in the water column. Throughout the invertebrates section, organisms may be referred to by their phylum name or, more generally, as marine invertebrates. In addition, there is a substantial variety of single-celled organisms, commonly referred to as protozoan, that represent several marine invertebrate phyla. These single-celled invertebrates and other invertebrate groups (e.g., flatworms, ribbon worms, and round worms) are not discussed further because their distributions are highly variable, and their populations would not be affected by project activities. The most common invertebrate groups in the Study Area that have the potential to be impacted by project activities are discussed below in greater detail.

ESA-listed invertebrates in the Study Area include black abalone (*Haliotis cracherodii*) and white abalone (*H. sorenseni*), while two other species of abalone, the green abalone (*H. fulgens*) and pink abalone (*H. corrugata*) are considered species of concern. Detailed information for each ESA-listed abalone species is presented in Sections 3.5.4.2.5.1 (Black Abalone [*Haliotis cracherodii*]) and 3.5.4.2.5.2 (White Abalone [*Haliotis sorenseni*]).

3.5.4.2.1 Sponges (Phylum Porifera)

Sponges include approximately 8,550 marine species worldwide and are classified in the Phylum Porifera (Van Soest et al., 2012; World Register of Marine Species Editorial Board, 2015). Sponges are bottom-dwelling, multicellular animals that can be best described as an aggregation of cells that perform different functions. Sponges are largely sessile and are common throughout the Study Area at all depths. Sponges are typically found on intermediate bottoms (unconsolidated substrate that is mostly gravel or cobble-sized) to hard bottoms, artificial structures, and biotic reefs. Sponges reproduce both sexually and asexually. Water flow through the sponge provides food and oxygen, and removes wastes (Pearse et al., 1987; University of California Berkeley, 2010a). This filtering process is an important coupler of processes that occur in the water column and on the bottom (Perea-Blázquez et al., 2012). Many sponges form calcium carbonate or silica spicules or bodies embedded in cells to provide structural support (Castro & Huber, 2000; Van Soest et al., 2012). Sponges provide homes for a variety of animals, including shrimp, crabs, barnacles, worms, brittle stars, sea cucumbers, and other sponges (Colin & Arneson, 1995b). Common subtidal sponges in the Study Area include the orange puffball sponge (*Tethya aurantia*) and orange encrusting sponge (*Clathria originalis*) (Kenner, 2018b).

Table 3.5-1: Common Taxonomic Groups of Marine Invertebrates in the Point Mugu Sea Range Study Area

Major Invertebrate Groups[1]		*Presence in Study Area*[2]	
Common Name (Classification)[3]	**Description**[4]	**Open Ocean**	**Coastal Waters**
Sponges (Porifera)	Mostly benthic animals; sessile filter feeders; large species have calcium carbonate or silica structures embedded in cells to provide structural support.	Bottom	Bottom
Anemones, hydroids, jellyfish, and corals (Cnidaria)	Benthic and pelagic animals with stinging cells; sessile corals and fan corals	Water column, bottom	Water column, bottom
Segmented worms (Annelida)	Mostly benthic, sedentary to highly mobile segmented marine worms (polychaetes); free-living and tube-dwelling species; predators, scavengers, herbivores, detritus feeders, deposit feeders, and filter or suspension feeders.	Bottom	Bottom
Bryozoans (Bryozoa)	Small, colonial animals with gelatinous or hard exteriors with a diverse array of growth forms; filter feeding; attached to a variety of substrates (e.g., rocks, plants, shells or external skeletons of invertebrates)	Bottom	Bottom
Cephalopods, bivalves, sea snails, chitons (Mollusca)	Soft-bodied benthic or pelagic predators, filter feeders, detritus feeders, and herbivore grazers; many species have a shell and muscular foot; in some groups, a ribbon-like band of teeth is used to scrape food off rocks or other hard surfaces. ESA-listed species in this group includes black and white abalone.	Water column, bottom	Water column, bottom
Shrimp, crabs, lobsters, barnacles, copepods (Arthropoda)	Benthic and pelagic predators, herbivores, scavengers, detritus feeders, and filter feeders; segmented bodies and external skeletons with jointed appendages	Water column, bottom	Water column, bottom
Sea stars, sea urchins, sea cucumbers (Echinodermata)	Benthic animals with endoskeleton made of hard calcareous structures (plates, rods, spicules); five-sided radial symmetry; many species with tube feet; predators, herbivores, detritus feeders, and suspension feeders.	Bottom	Bottom

[1]Major species groups (those with more than 1,000 species) are based on the World Register of Marine Species (World Register of Marine Species Editorial Board, 2015) and Catalogue of Life (Roskov et al., 2015).
[2]Presence in the Study Area includes open ocean areas and coastal waters of the California Current. Occurrence on or within seafloor (bottom or benthic) or water column (pelagic) pertains to juvenile and adult stages; however, many phyla may include pelagic planktonic larval stages.
[3]Classification generally refers to the rank of phylum.
[4]Benthic = a bottom-dwelling organism associated with seafloor or substrate; planktonic = an organism (or life stage of an organism) that drifts in pelagic (water) environments; nekton = actively swimming pelagic organism.
Note: ESA = Endangered Species Act

3.5.4.2.2 Anemones, Hydroids, Jellyfish, and Corals (Phylum Cnidaria)

There are over 10,000 marine species within the phylum Cnidaria worldwide (World Register of Marine Species Editorial Board, 2015), although there is taxonomic uncertainty within some groups (Veron, 2013). Cnidarians are organized into four classes: Anthozoa (sea anemones, sea pens, sea pansies), Hydrozoa (hydroids and hydromedusae), Scyphozoa (true jellyfish), and Cubozoa (box jellyfish, sea wasps). Individuals are characterized by a simple digestive cavity with an exterior mouth surrounded by tentacles. Microscopic stinging capsules known as nematocysts are present (especially in the tentacles) in all cnidarians and are a defining characteristic of the phylum. The majority of species are carnivores that eat zooplankton, small invertebrates, and fishes. However, many species feed on plankton and dissolved organic matter, or contain symbiotic dinoflagellate algae (zooxanthellae) that produce nutrients by photosynthesis (Brusca & Brusca, 2003; Dubinsky & Berman-Frank, 2001; Lough & van Oppen, 2009). Representative predators of cnidarians include sea slugs, snails, crabs, sea stars, jellyfish-eating fishes, and sea turtles. Cnidarians may be solitary or may form colonies.

Cnidarians have many diverse body shapes but may generally be categorized as one of two basic forms: polyp and medusa. The polyp form is tubular and sessile, attached at one end with the mouth surrounded by tentacles at the free end. Cup corals and sea anemones are examples of the polyp form. The medusa form is bell- or umbrella-shaped (e.g., jellyfish), with tentacles typically around the rim. The medusa form generally is pelagic, although there are exceptions. Many species alternate between these two forms during their life cycle. All cnidarian species are capable of sexual reproduction, and many cnidarians also reproduce asexually. The free-swimming larval stage is usually planktonic, but is benthic in some species.

Although corals in temperate waters, such as in the Study Area, are not reef-building, some coral species provide vertical relief and habitat that supports many organisms. For example, a single dead colony of Christmas tree black coral (*Antipathes dendrochristos*) observed by a submersible off Southern California was colonized by over 2,500 individual invertebrates, including other cnidarians (sea anemones), crustaceans, echinoderms, molluscs, and polychaete worms (Love et al., 2007). Surveys using trawls, submersibles, and remotely operated vehicles conducted on outer continental shelf bank and rock outcrops off Southern California have documented numerous coral species, including scleractinian stony corals, antipatharian black corals, gorgonian octocorals (sea fans), alcyonacean soft corals, pennatulacean octocorals (sea pens), and stylasterine hydrocoral (Etnoyer & Morgan, 2003; Whitmire & Clarke, 2007; Yoklavich et al., 2013).

Most of the habitat-forming deep-sea corals in Southern California are anthozoans and hydrozoans (Etnoyer & Morgan, 2003; Etnoyer & Morgan, 2005). Deep-water corals have been documented throughout the Southern California Bight (generally considered to be the area between Point Conception and San Diego, California). Deep-water areas off the California coast, including the Channel Islands National Marine Sanctuary, support numerous corals such as sea fans (gorgonians), *Lophelia pertusa*, scleractinians such as the cup coral *Caryophyllia arnoldi*, and black corals (National Oceanic and Atmospheric Administration & Southwest Fisheries Science Center, 2010; Whitmire & Clarke, 2007). At least 26 taxa of deep corals were recorded at a site within the Channel Islands sanctuary (Clarke et al., 2015). Large populations of hydrocorals occur at Tanner, Cortes, and Farnsworth Banks, offshore of Southern California (Southern California Marine Institute, 2016). Much of the rocky area of Farnsworth Bank to depths of 66 meters (m) was found to be covered by the hydrocoral *Stylaster californicus* (Clarke et al., 2015). Surveys of a rocky bank south of Anacapa Island (depths of 97–314 m) found gorgonians and the black coral *A. dendrochristos* to be relatively abundant. Additional surveys of a nearby bank at depths of 275–900 m documented numerous corals, primarily including *A. dendrochristos*, the soft mushroom coral *Heteropolypus ritteri*, several sea fan species, *L. pertusa*, the cup coral *Desmophyllum dianthus*, and the sea pen *Halipteris californica* (on soft sediment only). Numerous species, including gold coral species, have been documented during various other surveys of banks off Southern California.

The greatest threat to deep-water coral in the Study Area is physical strike and disturbance resulting from human activities. Deep corals are susceptible to physical disturbance due to the branching and fragile growth form of some species, slow growth rate (colonies can be hundreds of years old), and low reproduction and recruitment rates. Fishing activities, particularly trawling, are the primary threats to deep corals (Boland et al., 2016; Hourigan et al., 2017; Packer et al., 2017; Rooper et al., 2016; Yoklavich et al., 2017). Marine debris is also a potential threat. For example, during one study in the Atlantic Ocean, a fishing trap, fishing line, balloon remnants, and ribbon were observed either lying on or wrapped around deep-sea corals located off the northeastern United States (Quattrini et al., 2015). Other potential human-caused threats to deep-water corals include coral harvesting (e.g., black corals), hydrocarbon exploration and extraction, cable and pipeline installation, and other bottom-disturbing activities (Boland et al., 2016; Clarke et al., 2015; Parrish et al., 2015). Natural threats consist of sedimentation and bioerosion of the substrate.

3.5.4.2.3 Segmented Worms (Phylum Annelida)

Segmented worms include approximately 14,000 currently accepted marine species worldwide in the phylum Annelida, although the number of potentially identified marine species is nearly 25,000 (World Register of Marine Species Editorial Board, 2015). Most marine annelids are in the class Polychaeta. Polychaetes are the most complex group of marine worms, with a well-developed respiratory and gastrointestinal system (Castro & Huber, 2000). Different species of segmented worms may be highly mobile or burrow in the bottom (soft to intermediate shore or bottom habitats) (Castro & Huber, 2000). Polychaete worms exhibit a variety of life styles and feeding strategies, and may be predators, scavengers, deposit-feeders, filter-feeders, or suspension feeders (Jumars et al., 2015). The variety of feeding strategies and close connection to the bottom make annelids an integral part of the marine food web (Levinton, 2009). Burrowing and agitating the sediment increases the oxygen content of bottom sediments and makes important buried nutrients available to other organisms. This allows bacteria and other organisms, which are also an important part of the food web, to flourish on the bottom. Benthic polychaetes also vary in their mobility, including sessile attached or tube-dwelling worms, sediment burrowing worms, and mobile surface or subsurface worms. Some polychaetes are commensal or parasitic. Many polychaetes have planktonic larvae.

Polychaetes are found throughout the Study Area inhabiting rocky, sandy, and muddy areas of the bottom, vegetated habitats, and artificial substrates. Some species of worms build rigid (e.g., *Diopatra* spp.) or sand-encrusted (*Phragmatapoma* spp.) tubes, and aggregations of these tubes form a structural habitat. Giant tube worms (*Riftia pachyptila*) are chemosynthetic (using a primary production process without sunlight) reef-forming worms living on hydrothermal vents of the abyssal oceans. Their distribution is poorly known in the Study Area.

3.5.4.2.4 Bryozoans (Phylum Bryozoa)

Bryozoans include approximately 6,000 marine species worldwide (World Register of Marine Species Editorial Board, 2015). They are small box-like, colony-forming animals that make up the “lace corals.” Colonies can be encrusting, branching, or free-living. Bryozoans may form habitat similar in complexity to sponges (Buhl-Mortensen et al., 2010). Bryozoans attach to a variety of surfaces, including intermediate and hard bottom, artificial structures, and algae, and feed on particles suspended in the water (Pearse et al., 1987; University of California Berkeley, 2010b). Bryozoans are of economic importance for bioprospecting (the search for organisms for potential commercial use in pharmaceuticals). As common biofouling organisms, bryozoans also interfere with boat operations and clog industrial water intakes and conduits. Bryozoans occur throughout the Study Area but are not expected at depths beyond the continental slope (Ryland & Hayward, 1991). Habitat-forming species are most common on temperate continental shelves with relatively strong currents (Wood et al., 2012). Species that occur in the California Current Large Marine Ecosystem include arborescent bryozoans of the genus *Bugula* and encrusting bryozoans of the genus *Schizoporella*.

3.5.4.2.5 Squid, Bivalves, Marine Snails, Chitons (Phylum Mollusca)

The phylum Mollusca includes approximately 45,000 marine species worldwide (World Register of Marine Species Editorial Board, 2015). These organisms occur throughout the Study Area, including open ocean areas, at all depths. Sea snails and slugs (gastropods), clams and mussels (bivalves), chitons (polyplacophorans), and octopus and squid (cephalopods) are examples of common molluscs in the Study Area. Snails and slugs occur in a variety of soft, intermediate, hard, and biogenic habitats. Chitons are typically found on hard bottom and artificial structures from the intertidal to littoral zone but may also be found in deeper water and on substrates such as aquatic plants. Many molluscs possess a muscular organ called a foot, which is used for mobility. Many molluscs also secrete an external shell (Castro & Huber, 2000), although some molluscs have an internal shell or no shell at all (National Oceanic and Atmospheric Administration, 2015). Sea snails and slugs eat fleshy algae and a variety of invertebrates, including hydroids, sponges, sea urchins, worms, other snails, and small crustaceans, as well as detritus (Castro & Huber, 2000; Colin & Arneson, 1995a). Clams, mussels, and other bivalves are filter feeders, ingesting suspended food particles (e.g., phytoplankton, detritus) (Castro & Huber, 2000). Chitons, sea snails, and slugs use rasping tongues, known as radula, to scrape food (e.g., algae) off rocks or other hard surfaces (Castro & Huber, 2000; Colin & Arneson, 1995a). Squid and octopus are active swimmers at all depths and use a beak to prey on a variety of organisms including fish, shrimp, and other invertebrates (Castro & Huber, 2000). Octopuses mostly prey on fish, shrimp, eels, and crabs (Wood & Day, 2005).

Important commercial, ecological, and recreational species of molluscs in the California Current Large Marine Ecosystem include multiple abalone species, California market squid (*Doryteuthis opalescens*) (Clark et al., 2005), keyhole limpet (*Megathura crenulata*), Kellet's whelk (*Kelletia kelletia*), various species of octopus, sea hare (*Aplysia* spp.), snails (*Lithopoma undosum*, *Tegula* spp.), and Pismo clam (*Tivela stultorum*). Only one species of abalone, the red abalone (*Haliotis rufescens*), is currently fished recreationally, north of San Francisco County. The abalone fishery is closed to all commercial fishing. Black abalone and white abalone are listed under the ESA, while the green abalone (*Haliotis fulgens*) and pink abalone (*Haliotis corrugata*) are designated as species of concern.

3.5.4.2.5.1 Black Abalone (*Haliotis cracherodii*)

<u>**Status and Management**</u>

The black abalone (*Haliotis cracherodii*) was listed as endangered under the ESA in 2009. A dramatic decline in abundance, likely caused by a disease known as withering syndrome (explained in more detail below), prompted closure of both the commercial and recreational fisheries in California. The State of California imposed a moratorium on black abalone harvesting throughout California in 1993 and on all abalone harvesting in central and Southern California in 1997 (Butler et al., 2009). Numerous California

State Marine Protected Areas provide additional protection for abalone. An Abalone Recovery Management Plan was adopted by the State of California in 2005.

NMFS prepared a status review for this species in 2009 (Butler et al., 2009) and announced in 2016 the intent to prepare an updated status review (Endangered and Threatened Species; Initiation of 5-Year Review for the Endangered Black Abalone and the Endangered White Abalone, 81 *Federal Register* 93902–93903 [December 22, 2016]). Critical habitat was designated for black abalone by NMFS in 2011 (Endangered and Threatened Wildlife and Plants: Final Rulemaking to Designate Critical Habitat for Black Abalone, 76 *Federal Register* 66806–66844 [October 27, 2011]). Designated critical habitat includes rocky intertidal and subtidal habitats from the mean higher high water line to a depth of approximately 6 m, as well as the waters encompassed by these areas. Designated critical habitat generally extends from Del Mar Landing Ecological Reserve to the Palos Verdes Peninsula, and includes several offshore islands within the PMSR. No testing or training activities occur in waters surrounding these islands, including those that are within the Channel Islands National Marine Sanctuary. In the final rule designating critical habitat for the species, San Nicolas Island (SNI) and San Clemente Island (SCI) were excluded from critical habitat under ESA Section 4(a)(3) based on conservation benefits provided by the Navy's Integrated Natural Resources Management Plans for black abalone in those areas (no explosives are used in the nearshore areas off SNI that would overlap habitat for black abalone). The critical habitat designation also identifies physical or biological features of the habitat, which are the features that support the life-history needs of the species. The physical or biological features considered essential for black abalone recovery are rocky substrate, food resources, juvenile settlement habitat, suitable water quality, and suitable nearshore circulation patterns.

Various projects are in place to monitor the status of the species, to understand and address withering syndrome, to improve reproduction, and to minimize illegal harvest. For instance, the Navy monitors black abalone populations on SCI and SNI and Point Loma, San Diego; and the species is managed under both the SCI Integrated Natural Resources Management Plan and SNI Integrated Natural Resources Management Plan, as well as the Naval Base Point Loma Integrated Natural Resources Management Plan. The Navy continues to fund and conduct surveys of rocky intertidal areas off SCI, SNI, and Point Loma, including surveys specifically for black abalone (Graham et al., 2014; Graham et al., 2018; Graham et al., 2016; Kenner, 2018a; Tierra Data, 2008).

Habitat and Geographic Range

The distribution of black abalone ranges approximately from Point Arena in Northern California to Bahia Tortugas and Isla Guadalupe in Mexico (Butler et al., 2009). Although the geographic range of black abalone extends to Northern California, the most abundant populations historically have occurred in the Channel Islands (Butler et al., 2009). A map of the black abalone range can be accessed on NMFS Office of Protected Resources website.

Black abalone live on rocky substrates in the high to low intertidal zone (with most animals found in the middle and lower intertidal) within the Study Area. They occur among other invertebrate species, including California mussels (*Mytilus californianus*), gooseneck barnacles (*Pollicipes polymerus*), and sea anemones (e.g., giant green anemone (*Anthopleura xanthogrammica*). Of the species of abalone in the waters of California, the black abalone inhabits the shallowest areas. It is rarely found deeper than 6 m, and smaller individuals generally inhabit the higher intertidal zones. Complex surfaces with cracks and crevices may be crucial habitat for juveniles and appear to be important for adult survival as well (Butler et al., 2009).

The black abalone monitoring sites were established on SNI in 1980 and first sampled in 1981 (Kenner, 2018a). During the first 10 years of monitoring, black abalone were very densely aggregated at the sites, with mean densities ranging from about 4 to 24 per square meter and with some quadrats having over 100 abalone stacked several deep. Withering syndrome is a disease affecting many abalone species (see below) and was first observed in black abalone at Santa Cruz Island in 1985 (Lafferty & Kuris, 1993), decimating those populations. During 2015 intertidal surveys, a total of 1,548 black abalone were counted and measured at three sites at SNI (Graham et al., 2016). In 2018, a total of 2,016 abalone were counted at nine sites at SNI, the highest count since 1996 (Kenner, 2018a). In 2019, a total of 2,022 abalone were counted at SNI (Kenner, 2020). These are positive signs for the black abalone population at SNI. After several years of fairly regular growth, the monitored population size is now at about 8.7 percent of the pre-withering syndrome average (Kenner, 2020).

Population Trends

Black abalone were generally abundant before 1985 in the coastal waters throughout the species' range, although abundance has historically not been considered high north of San Francisco. Substantial populations also occurred in the coastal waters of the Channel Islands of Southern California. In the early 1970s, the black abalone constituted the largest abalone fishery in California. Black abalone populations south of Monterey County, California, have experienced 95 percent or greater declines in abundance since the mid-1980s as a result of fishing pressure in combination with withering syndrome (Neuman et al., 2010). Withering syndrome is caused by the bacteria species *Candidatus Xenohaliotis californiensis*, which attacks the lining of the abalone's digestive tract, inhibiting the production of digestive enzymes, which ultimately causes the muscular "foot" to wither and atrophy. This impairs the abalone's ability to adhere to rocks (Butler et al., 2009), making it more vulnerable to predation or starvation.

Major declines in abundance in the Channel Islands, the primary fishing grounds for this species before closure of the abalone fishery, have severely reduced the population as a whole (Butler et al., 2009). The Black Abalone Status Review Team estimates that, unless effective measures are put in place to counter the population decline caused by withering syndrome and overfishing, the species will likely be extinct within 30 years (Butler et al., 2009). SNI is one of the only locations in Southern California where black abalone have been increasing and where multiple recruitment events have occurred since 2005 (Butler et al., 2009).

Predator and Prey Interactions

The black abalone diet varies with life history stage. As larvae, black abalone receive nourishment from their egg yolks and do not actively feed. Settled abalone clamp tightly to rocky substrates and feed on crustose coralline algal matter that they scrape from the rocks. Young juveniles feed on bottom-dwelling diatoms, bacterial films, and microflora. As they increase in size and become less vulnerable to predation, abalone move into more open locations on rocks (though still cryptic) to forage. Adult black abalone feed primarily on drifting plant fragments and attached macroalgae (Butler et al., 2009; Smith et al., 2003). The primary predators of abalone are fish, sea otters, sea stars, and a variety of invertebrates, as well as humans through illegal harvesting (National Oceanic and Atmospheric Administration, 2018; Smith et al., 2003).

Species-Specific Threats

The black abalone population is declining as a consequence of historical overfishing and ongoing threats of withering syndrome, illegal harvest, pollution, and natural predation. The spread of withering syndrome is enhanced by periods of ocean warming, such as El Niño events (Neuman et al., 2010). Although there is no documented causal link between withering syndrome and long-term climate change, historical patterns suggest that ocean warming may increase the susceptibility of black abalone to the disease. Decreased population density is an additional factor in the species decline (Neuman et al., 2010). The black abalone is a broadcast spawner (gametes released into the water and fertilization occurs externally), and simultaneous spawning by males and females in close proximity (within a few feet) is required for successful reproduction. In areas where black abalone have been overfished or otherwise reduced, the distance between adult males and females may be too great or the population density too low to sustain local populations (Butler et al., 2009; Neuman et al., 2010). There is some concern that the invasive macroalga *Sargassum horneri*, first documented off Southern California in 2003 and currently distributed in coastal waters from Santa Barbara to central Baja California, Mexico, has the potential to affect black abalone populations. Long-term ecological implications of the presence of the invasive species are uncertain but potentially include displacement of native kelp (Kaplanis et al., 2016; Marks et al., 2015), which is a food source for black abalone.

3.5.4.2.5.2 White Abalone (*Haliotis sorenseni*)

Status and Management

The white abalone (*Haliotis sorenseni*) was listed as endangered under the ESA in 2001 and is recognized as one stock (Hobday & Tegner, 2000). Overfishing in the 1970s reduced the population to such low densities that successful reproduction was severely restricted. White abalone populations continue to be threatened primarily by reproductive failure (Hobday et al., 2001; National Marine Fisheries Service & Southwest Regional Office, 2008). Critical habitat is not designated for this species.

The State of California suspended all forms of harvesting of the white abalone in 1996 and, in 1997, imposed an indefinite moratorium on the harvesting of all abalone in central and Southern California (National Marine Fisheries Service & Southwest Regional Office, 2008). NMFS determined that informing the public of the locations of critical habitat, which includes areas where white abalone still exist, would increase the risk of illegal harvesting of white abalone (National Marine Fisheries Service & Southwest Regional Office, 2008). Potential habitat may exist between Point Conception, California, and the California/Mexico border, with much of it occurring in the isolated, deep waters off the Channel Islands. In reaction to concerns over the status of white abalone, the White Abalone Restoration Consortium was formed to propagate a captive-reared stock to enhance the depleted wild stock (National Marine Fisheries Service & Southwest Regional Office, 2008). National Oceanic and Atmospheric Administration Fisheries and its partners are supporting a captive breeding program at the University of California, Davis – Bodega Marine Laboratory. Using aquaculture techniques, the goal of this program is to produce captive-bred animals that can be used to establish self-sustaining white abalone populations in the wild.

Habitat and Geographic Range

The white abalone is a well-concealed, sessile, bottom-dwelling species that prefers reefs and rock piles with low relief areas surrounded by sandy areas (Hobday & Tegner, 2000). White abalone in the Southern California Bight typically inhabit depths ranging from about 20 to 60 m, with the highest densities occurring between 40 and 50 m (Butler et al., 2006). White abalone were found in waters deeper than other abalone species along the west coast of North America (Hobday et al., 2001). Overall, habitat associations of white abalone depend on its main food sources, drift macroalgae and a variety of red algae (National Oceanic and Atmospheric Administration, 2016). Thus, depth distribution is limited by water clarity and light penetration as well as by the availability of hard substrate or anchoring points on the bottom (Butler et al., 2006). Evidence suggests that white abalone prefer the sand and rock interface at the reef's edge, rather than the middle sections of reefs. Sand channels may be important for movement and concentration of drifting fragments of macroalgae and red algae (National Marine Fisheries Service & Southwest Regional Office, 2008). Postlarval and juvenile individuals often occur in sheltered areas to decrease susceptibility to predation, while adults occur in more open areas.

White abalone were historically found between Point Conception, California, and Punta Abreojos, Baja California, Mexico, at depths as shallow as 5 m (National Marine Fisheries Service & Southwest Regional Office, 2008). The current range in California appears similar to that of the historical range, although the species occurs in extremely reduced numbers. Information on the current range off Baja California is not available (National Marine Fisheries Service & Southwest Regional Office, 2008).

This species has historically been reported to occur within the subtidal waters of SNI (U.S. Department of the Navy, 2015). Though limited documentation post-1980 exists on the white abalone population at SNI, this species has experienced dramatic declines throughout its range. Except for some isolated survivors, the species is distributed only around the southern Channel Islands and along various banks outside the Study Area (Hobday & Tegner, 2000; Rogers-Bennett et al., 2002).

Population Trends

White abalone were once abundant throughout their range, but were more common and abundant along the coast in the northern and southern portions. Since the 1970s, the white abalone population has experienced a 99 percent reduction in density (National Marine Fisheries Service & Southwest Regional Office, 2008). Between 2002 and 2010, decreases in abundance (approximately 78 percent) and density (33–100 percent depending on depth and survey year) have been reported at Tanner Bank, an area of historically high abundance (greater than one animal per square meter) (Butler et al., 2006). An increase in the size distribution over this same time period suggests individuals in the white abalone population are growing larger (which indicates increased age) with little or no indication of adequate recruitment success. With a dispersed population of aging individuals, prospects for recruitment remain low without management intervention, such as outplanting of healthy, captive-bred white abalone in suitable habitat (Stierhoff et al., 2012). Captive breeding programs are currently in place to develop white abalone for introduction into the ocean, but outplanting has not occurred to date (Fell, 2015; National Oceanic and Atmospheric Administration, 2016). Personnel at the Space and Naval Warfare Systems Center at San Diego have previously outplanted green abalone (Navy Currents Magazine, 2011), but they have not done so with additional abalone species.

Various researchers have conducted submersible surveys off Tanner and Cortes Banks to map abalone habitat structure, examine distribution, and estimate the population size (Butler et al., 2006; Davis et al., 1998; Hobday & Tegner, 2000). They recorded 258 animals, with 168 recorded on Tanner Bank in 2002, at depths ranging from 32 to 55 m. In 2004, 35 individuals were recorded at Tanner Bank, 12 at Cortes Bank, and 5 off SCI. The 2012 population estimate of 564 individuals at SCI represented a moderate increase from the estimate of 353 individuals in 2005 (Stierhoff et al., 2014).

In July 2016, the U.S. Navy and NMFS entered into a seven-year Memorandum of Agreement to fund projects benefitting white abalone recovery (U.S. Department of the Navy & National Oceanic and Atmospheric Administration, 2016). The activities, which include field and laboratory projects, will be focused on Tanner and Cortes Banks but will also occur at SCI and Point Loma. Programs included in the agreement consist of field surveys and management assessments, development of tagging methods, disease studies, genetic evaluation, and outplanting monitoring.

Predator and Prey Interactions

Similar to black abalone, the white abalone diet varies with life history stage. As larvae, white abalone do not actively feed while in the planktonic stage. After settling on suitable substrate, abalone clamp tightly to rocky substrates and feed on algal matter scraped from the rocks or trapped under their shells. Young juveniles feed on bottom-dwelling diatoms, bacterial films, and benthic microflora. As they increase in size and become less vulnerable to predation, abalone leave their sheltered habitat to forage. Adult white abalone feed primarily on drifting fragments and attached macroalgae (National Marine Fisheries Service & Southwest Regional Office, 2008). Predators of white abalone include sea otters, fish, sea stars, crabs, spiny lobsters, and octopuses, as well as humans through illegal harvesting (Hobday & Tegner, 2000).

Species-Specific Threats

White abalone face similar threats to those of the black abalone (e.g., historical overharvesting, current low population densities, withering syndrome, competition with urchins and other abalone species for food, and illegal harvest). Low population density and illegal harvest are considered the primary current threats (National Marine Fisheries Service & Southwest Regional Office, 2008). However, because of the small population of white abalone, impacts on the remaining population are magnified.

3.5.4.2.6 Shrimp, Crab, Lobster, Barnacles, Copepods (Phylum Arthropoda)

Shrimp, crabs, lobsters, barnacles, and copepods are animals with an exoskeleton, which is a skeleton on the outside of the body (Castro & Huber, 2000), and are classified as crustaceans in the Phylum Arthropoda. The exoskeletons are made of a polymer called chitin, similar to cellulose in plants, to which the animals add other compounds to achieve flexibility or hardness. There are over 57,000 marine arthropod species, with about 53,000 of these belonging to the subphylum Crustacea (World Register of Marine Species Editorial Board, 2015). These organisms occur throughout the Study Area at all depths. Crustaceans may be carnivores, omnivores, predators, or scavengers, preying on molluscs (primarily gastropods), other crustaceans, echinoderms, small fishes, algae, and seagrass. Barnacles and some copepods are filter feeders, extracting algae and small organisms from the water (Levinton, 2009). Copepods may also be parasitic, affecting most phyla of marine animals (Walter & Boxshall, 2017). As a group, arthropods occur in a wide variety of habitats. Shrimp, crabs, lobsters, and copepods may be associated with soft to hard substrates, artificial structures, and biogenic habitats. Barnacles inhabit hard and artificial substrates.

Important commercial, ecological, and recreational species of Crustacea in the Study Area include the spot shrimp (*Pandalus platyceros*), ridgeback rock shrimp (*Sicyonia ingentis*), rock crab (*Cancer* species), sheep crab (*Loxorhynchus grandis*), and California spiny lobster (Clark et al., 2005; Graham et al., 2016; Kenner, 2018b).

3.5.4.2.7 Sea Stars, Sea Urchins, Sea Cucumbers (Phylum Echinodermata)

Organisms in this phylum include over 7,000 marine species, such as sea stars, sea urchins, and sea cucumbers (World Register of Marine Species Editorial Board, 2015). Asteroids (e.g., sea stars), echinoids (e.g., sea urchins), holothuroids (e.g., sea cucumbers), ophiuroids (e.g., brittle stars and basket stars), and crinoids (e.g., feather stars and sea lilies) are symmetrical around the center axis of the body (Mah & Blake, 2012). Echinoderms occur at all depth ranges from the intertidal zone to the abyssal zone and are almost exclusively benthic, potentially found on all substrates and structures. Most echinoderms have separate sexes, but a few species of sea stars, sea cucumbers, and brittle stars have both male and female reproductive structures. Many species have external fertilization, releasing gametes into the water to produce planktonic larvae, but some brood their eggs and release free-swimming larvae (Mah & Blake, 2012; McMurray et al., 2012). Many echinoderms are either scavengers or predators on sessile organisms such as algae, sponges, clams, and oysters. Some species, however, filter food particles from sand, mud, or water. Predators of echinoderms include a variety of fish species (e.g., triggerfish, eels, rays, sharks), crabs, shrimps, octopuses, birds, and other echinoderms (e.g., sea stars).

Echinoderms are found throughout the Study Area. Important commercial, ecological, and recreational species of echinoderms in the California Current Large Marine Ecosystem include California sea cucumbers (*Parastichopus californicus*), sea stars (*Pisaster* spp.), red sea urchin (*Strongylocentrotus franciscanus*), and purple sea urchin (*S. purpuratus*) (Clark et al., 2005). Beginning in 2013, large numbers of sea stars have died along the west coast of North America due to sea star wasting disease (Hewson et al., 2014; Miner et al., 2018). The virus causing the disease has also been found in sea urchins and sea cucumbers, although mass die-offs have not been documented for these taxa.

3.5.5 Environmental Consequences

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 invertebrates, 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 3.5-2 presents the proposed testing and training activities and stressors that could potentially affect marine invertebrates. The stressors analyzed for potential impacts on marine invertebrates include explosives, physical disturbance and strike from military expended materials, and ingestion. Stressors such as acoustic, energy (directed energy and high-energy lasers), and entanglement were analyzed in several previous Navy environmental documents (U.S. Department of the Navy, 2018a, 2018b) and determined to not be applicable to marine invertebrates primarily because they are stressors that do not apply to marine invertebrates (e.g., acoustics, due to the lack of hearing capabilities of marine invertebrates or entanglement because no proposed Navy activities have the potential to entangle a marine invertebrate). In addition, proposed Navy activities such as subsurface-to-surface testing would not impact marine invertebrates since this activity takes place in the upper water column. Some substressors such as physical disturbance and strike by vessels or in-water devices would not occur because the majority of invertebrates are not in the water column, and the proposed Navy activities are not using seafloor devices that would have the potential to impact abalone habitat.

Most marine invertebrate populations extend across wide areas containing hundreds or thousands of discrete patches of suitable habitat. Sessile invertebrate populations may be connected by complex currents that carry adults and young from place to place. Impacts on such widespread populations are difficult to quantitatively evaluate in terms of Navy testing and training activities that occur intermittently and in relatively small patches in the Study Area. Invertebrate habitats generally cover enormous areas (see Section 3.3, Marine Habitats); in this context, impacts on marine invertebrates from explosives at the surface, a physical strike or disturbance, or ingestion of military expended materials may impact individual organisms, but not to the extent that viability of populations of common species would be impacted.

Table 3.5-2: Summary of Stressors Analyzed for Marine Invertebrates from Navy Testing and Training Activities Within the PMSR

Activity Category	Stressor	Potential Impacts	ESA Determination
Air-to-Air	Physical Disturbance/Strike	Some marine invertebrates could experience physical trauma that would result in injury or death, stress or behavioral responses, abrasion, and shading. Impacts would not cause lasting effects on the survival, growth, recruitment, or reproduction of marine invertebrate species at the population level.	Discountable or insignificant and not likely to adversely affect ESA-listed abalone
	Ingestion	Most invertebrates would not be able to ingest expended items because of their large size. However, some small items and fragments of larger items such as targets could potentially be ingested. Impacts on marine invertebrate populations due to military expended materials would probably not be detectable.	Discountable or insignificant and not likely to adversely affect ESA-listed abalone
Air-to-Surface	Explosives	Some marine invertebrates would likely be injured or killed during an explosion, but the numbers affected would be small relative to overall population sizes and would not impact survival, growth, recruitment, or reproduction of populations or subpopulations.	Discountable or insignificant and not likely to adversely affect ESA-listed abalone
	Physical Disturbance/Strike	Some marine invertebrates could experience physical trauma that would result in injury or death, stress or behavioral responses, abrasion, and shading. Impacts would not cause lasting effects on the survival, growth, recruitment, or reproduction of marine invertebrate species at the population level.	Discountable or insignificant and not likely to adversely affect ESA-listed abalone
	Ingestion	Most invertebrates would not be able to ingest expended items because of their large size. However, some small items and fragments of larger items such as targets could potentially be ingested. Impacts on marine invertebrate populations due to military expended materials would probably not be detectable.	Discountable or insignificant and not likely to adversely affect ESA-listed abalone

Table 3.5-2: Summary of Stressors Analyzed for Marine Invertebrates from Navy Testing and Training Activities Within the PMSR (continued)

Activity Category	Stressor	Potential Impacts	ESA Determination
Surface-to-Air	Physical Disturbance/Strike	Some marine invertebrates could experience physical trauma that would result in injury or death, stress or behavioral responses, abrasion, and shading. Impacts would not cause lasting effects on the survival, growth, recruitment, or reproduction of marine invertebrate species at the population level.	Discountable or insignificant and not likely to adversely affect ESA-listed abalone
	Ingestion	Most invertebrates would not be able to ingest expended items because of their large size. However, some small items and fragments of larger items such as targets could potentially be ingested. Impacts on marine invertebrate populations due to military expended materials would probably not be detectable.	Discountable or insignificant and not likely to adversely affect ESA-listed abalone
Surface-to-Surface	Explosives	Some marine invertebrates would likely be injured or killed during an explosion, but the numbers affected would be small relative to overall population sizes, and would not impact survival, growth, recruitment, or reproduction of populations or subpopulations.	Discountable or insignificant and not likely to adversely affect ESA-listed abalone
	Physical Disturbance/Strike	Some marine invertebrates could experience physical trauma that would result in injury or death, stress or behavioral responses, abrasion, and shading. Impacts would not cause lasting effects on the survival, growth, recruitment, or reproduction of marine invertebrate species at the population level.	Discountable or insignificant and not likely to adversely affect ESA-listed abalone
	Ingestion	Most invertebrates would not be able to ingest expended items because of their large size. However, some small items and fragments of larger items such as targets could potentially be ingested. Impacts on marine invertebrate populations due to military expended materials would probably not be detectable.	Discountable or insignificant and not likely to adversely affect ESA-listed abalone

Table 3.5-2: Summary of Stressors Analyzed for Marine Invertebrates from Navy Testing and Training Activities Within the PMSR (continued)

Activity Category	Stressor	Potential Impacts	ESA Determination
Subsurface-to-Surface	Explosives	Some marine invertebrates would likely be injured or killed during an explosion, but the numbers affected would be small relative to overall population sizes, and would not impact survival, growth, recruitment, or reproduction of populations or subpopulations.	Discountable or insignificant and not likely to adversely affect ESA-listed abalone
	Physical Disturbance/Strike	Some marine invertebrates could experience physical trauma that would result in injury or death, stress or behavioral responses, abrasion, and shading. Impacts would not cause lasting effects on the survival, growth, recruitment, or reproduction of marine invertebrate species at the population level.	Discountable or insignificant and not likely to adversely affect ESA-listed abalone
	Ingestion	Most invertebrates would not be able to ingest expended items because of their large size. However, some small items and fragments of larger items such as targets could potentially be ingested. Impacts on marine invertebrate populations due to military expended materials would probably not be detectable.	Discountable or insignificant and not likely to adversely affect ESA-listed abalone

3.5.5.1 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, 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 invertebrates, but would not measurably improve the overall distribution or abundance of marine invertebrates.

3.5.5.2 Alternative 1 (Preferred Alternative)

3.5.5.2.1 Explosives

Under Alternative 1, marine invertebrates would be exposed to surface explosions and associated underwater impulsive sounds from high-explosive munitions such as bombs and missiles during air-to-surface, surface-to-surface activities, and subsurface-to-surface (see Table 3.0-7). Explosives could be used throughout the Study Area. However, most explosives are more frequently used outside

12 nautical miles (NM) of land for explosives within the larger bins (e.g., >E3), outside of 3 NM from the coastline, the Channel Islands, and sensitive marine habitats. 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 1 would increase compared to current environmental baseline conditions (see Table 3.0-7).

Explosives produce pressure waves that can harm invertebrates in the vicinity of where they typically occur, mostly offshore surface waters where only zooplankton, squid, and jellyfish typically occur. The overall impacts of explosions on widespread invertebrate populations would likely be undetectable. Although individuals of marine invertebrate species would likely be injured or killed during an explosion, the number of such invertebrates affected would be small relative to overall population sizes, and activities would be unlikely to impact survival, growth, recruitment, or reproduction of populations or subpopulations. Therefore, potential impacts from explosions on marine invertebrates would be less than significant.

ESA-listed species, such as black abalone, are found primarily within the intertidal zone where explosions do not occur, but also occur in the subtidal zone to a depth of about 20 ft., while white abalone occur at greater depths. Both species would not be exposed to pressure waves from explosive detonations associated with testing and training exercises because detonations are not expected to occur in the vicinity of the hard substrate or within the depth range associated with black abalone and white abalone.

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 ESA-listed black and white abalone. The Navy has consulted with NMFS, as required by section 7(a)(2) of the ESA.

3.5.5.2.2 Physical Disturbance and Strike

Military expended materials would be deposited throughout the Study Area during testing and training activities. However, the majority of military expended materials would be deposited in areas located away from the coastline on the continental shelf and slope and beyond (e.g., abyssal plain). Marine invertebrates may be exposed to physical disturbance and strike risk from (1) all sizes of non-explosive practice munitions, (2) fragments from high-explosive munitions, and (3) expendable targets and target fragments. Physical disturbance or strikes by military expended materials on marine invertebrates is possible at the water's surface, through the water column, and on the bottom. However, disturbance or strike impacts on marine invertebrates by military expended materials falling through the water column are not very likely because military expended materials do not generally sink rapidly enough to cause strike injury. Exposed invertebrates would likely experience only temporary displacement as the object passes by. Therefore, the discussion of military expended materials disturbance and strikes in this section will focus on items at the water's surface and on the bottom.

Potential impacts on invertebrates generally consist of physical trauma, stress or behavioral responses, abrasion, and shading. Military expended materials may injure or kill invertebrates by directly striking individuals, causing breakage (particularly for species with exoskeletons or that build structures), crushing, or other physical trauma. Direct strike may result from the initial impact, or may occur after items fall through the water column and settle onto invertebrates or are moved along the bottom by water currents or gravity. Expended items may also bury or smother organisms; however, depending on the size of the expended item relative to the animal, some mobile invertebrates may be able to move or dig out from underneath an item. In addition to physical strike, military expended materials may disturb individuals and cause them to change locations, behaviors, or activities. Disturbance could therefore result in impacts such as briefly increased energy expenditure, decreased feeding, and increased susceptibility to predation. Expended items could also cause increased turbidity that could affect filter-feeding species, although such impacts are likely to be localized and temporary. Activities involving military expended materials are also not expected to yield any behavioral changes or lasting effects on the survival, growth, recruitment, or reproduction of marine invertebrate species at the population level.

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 invertebrates would increase compared to current environmental baseline conditions (see Table 3.0-12). However, testing and training activities that would generate military expended material large enough to cause injury to marine invertebrates would generally occur in offshore areas where the presence and abundance of marine invertebrates is generally low.

Therefore, potential impacts on marine invertebrates from a physical disturbance or strike of military expended material would be less than significant.

In general, the Navy does not conduct testing and training activities that use military expended material in shallow-water, rocky areas where ESA-listed black abalones typically occur. Materials are primarily expended far from shore, in the open ocean. Some military expended materials may be expended in the nearshore waters of San Nicolas Island, where they could sink to the bottom and have localized impacts on invertebrates surrounding the island. Military expended materials would generally not be expected to affect black abalone because of the limited amount of items that would be expended in water depths less than 20 ft. It is conceivable for an item expended offshore to drift shoreward and reach water depths associated with black abalone occurrence and designated critical habitat. It would be highly unlikely for military expended materials to drift into waters known to support white abalone, such as Cortes and Tanner Banks, a distance of over 8 miles and 4 miles outside of the PMSR boundary, respectively. These offshore pinnacles appear to be important habitat for white abalones, and a relatively large population occurs at Tanner Bank (Butler et al., 2006). The potential to impact white abalones is further decreased by the low abalone population density, the widely dispersed use of expendable materials, and the distance from where military materials would be expended

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 ESA-listed black and white abalone. The Navy has consulted with NMFS, as required by section 7(a)(2) of the ESA.

3.5.5.2.3 Ingestion

Military expended materials deposited throughout the Study Area, such as non-explosive practice munitions (small- and medium-caliber), fragments from high-explosives, fragments from targets, chaff and flares, and chaff and flare accessories (including end caps, compression pads or pistons, and o-rings), could be ingested by marine invertebrates during testing and training activities. Ingestion could occur at the surface, in the water column, or at the bottom, depending on the size and buoyancy of the expended object and the feeding behavior of the animal. Floating material is more likely to be eaten by animals that may feed at or near the water surface (e.g., jellyfish, squid), while materials that sink to the bottom present a higher risk to both filter-feeding sessile (e.g., sponges) and bottom-feeding animals (e.g., crabs). Most military expended materials and fragments of military expended materials are too large to be ingested by marine invertebrates, and relatively large predatory or scavenging individuals are unlikely to consume an item that does not visually or chemically resemble food (Koehl et al., 2001; Polese et al., 2015).

If expended material is ingested by marine invertebrates, the primary risk is blockage in the digestive tract. Most military expended materials are relatively inert in the marine environment and are not likely to cause injury or mortality via chemical effects. However, pollutants (e.g., heavy metals and polychlorinated biphenyls) may accumulate on the plastic components of some military expended materials. Plastic debris pieces collected at various locations in the North Pacific Ocean had polycyclic aromatic hydrocarbons and pesticides associated with them (Rios et al., 2007). Relatively large plastic pieces could be ingested by some species. However, filter- or deposit-feeding invertebrates have the greatest potential to ingest small plastic items, and any associated pollutants could harm the individual animal or subsequently be incorporated into the food chain.

Very few invertebrates are large enough to ingest intact military expended material such as ordnance (small- and medium-caliber munitions and casings) (see Table 3.0-12). The potential impact resulting from ingestion of these items would be limited to a few larger taxa such as squid and octopus. Other military expended materials such as targets, large-caliber projectiles, intact bombs, and marine markers are too large for any marine invertebrate to consume. The potential for marine invertebrates to encounter fragments or military expended materials of ingestible size such as chaff increases as the military expended materials degrade into smaller fragments over months to decades. Marine invertebrates may occasionally encounter chaff fibers and incidentally ingest chaff when they ingest prey or water. Literature reviews and controlled experiments suggest that chaff poses little environmental risk to marine organisms at concentrations that could reasonably occur from military testing and training (Arfsten et al., 2002; U.S. Department of the Navy, 1999). Intact munitions, fragments of munitions, and other items could degrade into metal and plastic pieces small enough to be consumed by indiscriminate feeders, such as some marine worms. Deposit-feeding, detritus-feeding, and filter-feeding invertebrates such as amphipods, polychaete worms, zooplankton, and mussels have been found to consume microscale plastic particles (microplastics) that result from the breakdown of larger plastic items (National Oceanic and Atmospheric Administration Marine Debris Program, 2014; Wright et al., 2013). Ingestion by these types of organisms is the most likely pathway for degraded military expended materials to enter the marine food web. Transfer of microplastic particles to higher trophic levels was demonstrated in one experiment (Setala et al., 2014). Ingestion of microplastics may result in physical effects such as internal abrasion and gut blockage, toxicity due to leaching of chemicals, and exposure to attached pollutants. Potentially harmful bacteria may also grow on microplastic particles (Kirstein et al., 2016). In addition, consumption of microplastics may result in decreased consumption of natural foods such as algae (Cole et al., 2013). Microplastic ingestion by marine worms was shown in one study to result in lower energy reserves (Wright et al., 2013). Microplastic ingestion has been documented in numerous marine invertebrates (e.g., mussels, worms, mysid shrimp, bivalve molluscs, and zooplankton (Cole et al., 2013; Hall et al., 2015; Setala et al., 2016; Wright et al., 2013).

Under Alternative 1, military expended materials associated with testing and training activities of fragment size that could potentially be ingested by marine invertebrates would increase compared to current environmental baseline conditions (see Table 3.0-12). Deposit- and detritus-feeding invertebrates could potentially ingest munitions fragments that have degraded to sediment size; and particulate metals may be taken up by suspension feeders and, as described above, may lead to physical effects such as internal abrasion and gut blockage, toxicity due to leaching of chemicals, and exposure to attached pollutants. Impacts on individuals are unlikely and impacts on populations would probably not be detectable. Therefore, potential impacts on marine invertebrates from ingestion of military expended material would be less than significant.

Potential impacts on ESA-listed abalone would be limited to individuals accidentally ingesting small fragments of military expended material that traveled from the surface and through the water column to the bottom. These species have the potential to accidentally ingest military expended materials as they scrape algae or biofilm (a thin layer of microorganisms) off hard substrates in shallow water. However, materials are primarily expended far from shore, in the open ocean, and likely would not drift into nearshore habitats where black abalone occur. It is also unlikely that military expended materials would drift and fall into offshore waters known to support white abalone, since the closest known white abalone populations are between 5 and 8 miles from the southern boundary of 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 ESA-listed black and white abalone. The Navy has consulted with NMFS, as required by section 7(a)(2) of the ESA.

3.5.5.3 Alternative 2

3.5.5.3.1 Explosives

Under Alternative 2, marine invertebrates 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, the overall impacts of explosions on widespread invertebrate populations would likely be undetectable. Although individuals of widespread marine invertebrate species would likely be injured or killed during an explosion, the number of such invertebrates affected would be small relative to overall population sizes, and activities would be unlikely to impact survival, growth, recruitment, or reproduction of populations or subpopulations. Therefore, potential impacts from explosions on marine invertebrates would be less than significant.

ESA-listed black abalone are found primarily within the intertidal zone where explosions do not occur, but also occur in the subtidal zone to a depth of about 20 ft., while ESA-listed white abalone occur at greater depths. Both species would not be exposed to pressure waves from explosive detonations associated with testing and training exercises because detonations are not expected to occur on the hard substrate or within the depth range associated with black abalone and white abalone. Therefore, potential impacts from explosions to marine invertebrates would be less than significant.

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 ESA-listed black and white abalone.

3.5.5.3.2 Physical Disturbance and Strike

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). As described above for Alternative 1, larger invertebrates in offshore areas such as squid and octopus could potentially ingest larger pieces of military expended materials, while deposit- and detritus-feeding invertebrates could potentially ingest fragments that have degraded to sediment size, and particulate metals may be taken up by suspension feeders. Impacts on individuals are unlikely and impacts on populations would probably not be detectable. Therefore, potential physical disturbance and strike impacts on marine invertebrates from military expended material would be less than significant.

Potential impacts on ESA-listed abalone would be limited to individuals accidentally ingesting small fragments of expended military materials that have traveled from the surface, through the water column, and have been deposited on hard substrate. Abalone would potentially ingest military expended material as they scrape algae or biofilm (a thin layer of microorganisms) off hard substrates in shallow water. However, materials are primarily expended far from shore, in the open ocean and likely would not drift into nearshore habitats where black abalone occur. It is also unlikely that military expended materials would drift and fall into offshore waters known to support white abalone, since the closest known white abalone populations are between 5 and 8 miles from the southern boundary of the Study Area.

Pursuant to the ESA, the use of military expended materials during testing and training activities as described under Alternative 2 may affect but is not likely to adversely affect ESA-listed black and white abalone.

3.5.5.3.3 Ingestion

Military expended materials deposited throughout the Study Area could be ingested by marine invertebrates during air-to-air, air-to-surface, surface-to-air, and surface-to-surface activities. Ingestion could occur at the surface, in the water column, or at the bottom, depending on the size and buoyancy of the expended object and the feeding behavior of the animal.

Under Alternative 2, military expended materials associated with testing and training activities of fragment size that could potentially be ingested by marine invertebrates would increase compared to current environmental baseline conditions (see Table 3.0-12). Deposit- and detritus-feeding invertebrates could potentially ingest munitions fragments that have degraded to sediment size; and particulate metals may be taken up by suspension feeders and, as described above, may lead to physical effects such as internal abrasion and gut blockage, toxicity due to leaching of chemicals, and exposure to attached pollutants. Impacts on individuals are unlikely and impacts on populations would probably not be detectable. Therefore, potential impacts on marine invertebrates from ingestion of military expended material would be less than significant.

Potential impacts on ESA-listed abalone would be limited to individuals accidentally ingesting small fragments of military expended material that traveled from the surface and through the water column to the bottom. These species have to potential to accidentally ingest military expended materials as they scrape algae or biofilm (a thin layer of microorganisms) off hard substrates in shallow water. However, materials are primarily expended far from shore, in the open ocean, and likely would not drift into nearshore habitats where black abalone occur. It is also unlikely that military expended materials would drift and fall into offshore waters known to support white abalone, since the closest known white abalone populations are between 5 and 8 miles from the southern boundary of the Study Area. Therefore, potential impacts on marine invertebrates from ingestion of military expended material would be less than significant.

Pursuant to the ESA, the use of military expended materials during testing and training activities as described under Alternative 2 may affect but is not likely to adversely affect ESA-listed black and white abalone.

3.5.5.4 Indirect Effects

Navy testing and training activities that could pose indirect impacts on marine invertebrates via habitat or prey include (1) explosives and explosive byproducts, (2) chemicals other than explosives, and (3) metals. Indirect stressors may impact benthic and pelagic invertebrates, gametes, eggs, and larvae by changes to sediment and water quality. Physical and biological features of ESA-listed black abalone critical habitat include rocky substrate, food resources, juvenile settlement habitat, suitable water quality, and suitable nearshore circulation patterns. Exemptions from critical habitat designation within the Study Area include areas offshore of San Nicolas Island. However, the exemptions do not preclude analysis of ESA-listed black abalones. Potential impacts on rocky substrate would be associated with physical effects such as breakage or covering. Potential impacts on water quality would be associated with introduction of metal, plastic, or chemical substances into the water column.

Indirect impacts of explosives and unexploded munitions on marine invertebrates via water are likely to be inconsequential. Most explosives and explosive degradation products have relatively low solubility in seawater. This means that dissolution occurs extremely slowly, and harmful concentrations of explosives and degradation products are not likely to occur in the water column. Also, the low concentration of materials delivered slowly into the water column is readily diluted by ocean currents and would be unlikely to concentrate in toxic levels.

Impacts on Habitat

The potential for explosions occurring near the surface to damage habitat for ESA-listed abalone is considered negligible. The largest explosives are used more than 12 NM from shore, where water depth is typically greater than 90 m, and explosive effects would not extend to the bottom at locations seaward of the coastal zone due to vertical compression of explosive impacts around the detonation point. Therefore, impacts on habitat potentially supporting ESA-listed abalone species would be limited to activities that are inadvertently conducted on or near unknown habitat areas. No impacts are expected to occur on hard structure considered an essential physical feature of black abalone critical habitat. Although critical habitat is not designated for white abalone, hard structure is an important habitat feature for this species as well.

Pursuant to the ESA, indirect effects, such as impacts on habitat from testing and training activities, as described above, may affect but are not likely to adversely affect ESA-listed abalone.

Impacts on Prey Availability

Indirect effects on invertebrate prey availability (including vegetation and phytoplankton) resulting from explosives, explosives byproducts, unexploded munitions, metals, and chemicals would likely be negligible overall, and population-level impacts on marine invertebrates are not expected. Because individuals of many invertebrate taxa prey on other invertebrates, mortality resulting from explosions or exposure to metals or chemical materials would reduce the number of invertebrate prey items available. A few species prey upon fish, and explosions and exposure to metals and chemical materials could result in a minor reduction in the number of fish available. However, as discussed above, explosive materials, metals, and chemicals would have a negligible effect on fishes. Therefore, indirect effects on invertebrates due to reduced fish prey availability are unlikely. Any vertebrate or invertebrate animal killed or significantly impaired by Navy activities could potentially represent an increase in food availability for scavenging invertebrates. None of the effects described above would likely be detectable at the population or subpopulation level.

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 ESA-listed abalone

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