3.8 Marine Invertebrates

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3.8 Marine Invertebrates

MARINE INVERTEBRATES SYNOPSIS

The United States Department of the Navy considered all potential stressors, and the following have been analyzed for marine invertebrates:

- Acoustic (sonar and other active acoustic sources; underwater explosives; swimmer defense airguns; weapons firing, launch and impact noise; aircraft noise; and vessel noise)
- Energy (electromagnetic devices)
- Physical disturbance and strike (vessels, in-water devices, military expended materials, and seafloor devices)
- Entanglement (fiber optic cables and guidance wires, and decelerators/parachutes)
- Ingestion (military expended materials)
- Secondary (impacts associated with sediments and water quality)

Preferred Alternative (Alternative 1)

- Acoustic: Pursuant to the Endangered Species Act (ESA), the use of sonar and other active acoustic sources; underwater explosives; swimmer defense airguns weapons firing, launch and impact noise; aircraft noise; and vessel noise may affect ESA-listed coral species.
- Energy: Pursuant to the ESA, the use of electromagnetic devices would have no effect on ESA-listed coral species.
- Physical Disturbance and Strike: Pursuant to the ESA, the use of vessels, in-water devices, and military expended materials may affect ESA-listed coral species. The use of military expended materials on FDM may affect ESA-listed coral species as a result of direct strikes from off island munitions. The use of seafloor devices would have no effect on ESA-listed coral species.
- Entanglement: Pursuant to the ESA, the use of fiber optic cables and guidance wires as well as decelerators/parachutes would have no effect on ESA-listed coral species.
- Ingestion: Pursuant to the ESA, the use of military expended materials would have no effect on ESA-listed coral species.
- Secondary: Pursuant to the ESA, secondary stressors would have no effect on ESA-listed coral species.
- There is no marine invertebrate critical habitat in the Study Area.
- Pursuant to the Essential Fish Habitat (EFH) requirements of the Magnuson-Stevens Fishery Conservation and Management Act and implementing regulations, the use of sonar and other acoustic sources, vessel noise, swimmer defense airguns, weapons firing noise, electromagnetic sources, vessel movement, in-water devices, and metal, chemical, or other material byproducts will have no adverse effect on sedentary invertebrate beds or reefs that constitute EFH or Habitat Areas of Particular Concern. The use of electromagnetic sources will have minimal and temporary adverse impact to invertebrates occupying water column EFH or Habitat Areas of Particular Concern. The use of explosives, military expended materials, seafloor devices, and explosives and explosive byproducts may have an adverse effect on EFH by reducing the quality and quantity of sedentary invertebrate beds or reefs that constitute EFH or Habitat Areas of Particular Concern.

3.8.1 INTRODUCTION

In this Environmental Impact Statement (EIS)/Overseas EIS (OEIS), marine invertebrates are evaluated based on their distribution and life history relative to the stressor or activity being considered. Activities are analyzed for their potential impact on marine invertebrates in general, on taxonomic groupings of marine invertebrates as appropriate, and on species listed under the Endangered Species Act (ESA) in the Mariana Islands Training and Testing (MITT) Study Area.

Invertebrates are animals without backbones, and marine invertebrates are a large and diverse group. Many of these species are important to humans ecologically and economically, providing essential ecosystem services (coastal protection) and income from commercial and recreational fisheries (Spalding et al. 2001). Because marine invertebrates occur in all habitats, activities that interact with the water column or the seafloor could impact countless zooplankton (e.g., copepods, fish eggs, larvae, and jellyfish), larger invertebrates living in water column (e.g., squid), and benthic invertebrates that live on or in the seafloor (e.g., clams, crabs).

The following subsections provide brief introductions to major taxonomic groups and federally listed species of marine invertebrates that occur in the Study Area. Profiles of these species, along with major taxonomic groups in the Study Area (as defined in Paulay 2003a), are described in this section. The National Oceanic and Atmospheric Administration (NOAA) Office of Protected Resources maintains a website that provides additional information on the biology, life history, species distribution (including maps), and conservation of listed, proposed, or candidate invertebrate species.

Essential Fish Habitat (EFH) under the Magnuson-Stevens Fishery Conservation and Management Act will be described in the Essential Fish Habitat Assessment (EFHA), and conclusions from the EFHA will be summarized in each substressor section.

3.8.1.1 Endangered Species Act – Listed Species

In response to a petition from the Center for Biological Diversity to list under the ESA and designate critical habitat for species of coral, National Marine Fisheries Service (NMFS) reviewed the status of 82 "candidate species" of corals. Candidate species are those petitioned species that are actively being considered for listing as endangered or threatened under the ESA, as well as those species for which NMFS has initiated an ESA status review that it has announced in the Federal Register (FR). In April 2012, NMFS completed a status review report and draft Management Report of the candidate species of corals. On 20 September 2013, an extension of the final determination on corals to be listed under the ESA was announced by NMFS (78 FR 57835).

Fifty-two species of coral found in the Study Area were potential candidates for listing under the ESA (National Oceanic and Atmospheric Administration 2010a; National Oceanic and Atmospheric Administration and U.S. Department of Commerce 2010). The presence or possible presence of these species in the Study Area has been noted by Randall (2003), Center for Biological Diversity (2009), and the International Union for Conservation of Nature.

On 7 December 2012, the NMFS published a proposed rule with the determination that 66 species of coral warranted listing under the ESA as either threatened or endangered (77 FR 73220–73252). Of these 66 species, 43 potentially occur within the Study Area (Table 3.8-1) based on their life histories (Brainard et al. 2011) and recent surveys (National Marine Fisheries Service 2012), which are described below (note that 44 species are presented in Table 3.8-1; *Montipora turgescens* was not proposed for listing but is part of the clade that was proposed for listing under the ESA). On 20 September 2013, an extension of the final determination on corals to be listed under the ESA was announced by the National Marine Fisheries Service (78 FR 57835), and on 25 October 2013 the National Marine Fisheries Service added three additional coral species to the list of candidate species being considered for listing under the ESA. These species, none of which occur in the Study Area, are *Cantharellus noumeae, Siderastrea glynni, and Tubastraea floreana*. Additional information regarding each coral species, including the Petition to List 82 Coral Species Under the ESA by the Center for Biological Diversity (Sakashita and Wolf 2009), can be accessed at the website maintained by the NMFS Office of Protected Resources.

On September 10, 2014, NMFS published a Final Rule (79 FR 53851) presenting the final listing determinations for the 66 species of coral. In total, 22 species of coral are now protected under the Endangered Species Act, including the two corals (elkhorn and staghorn) listed as threatened in 2006. NMFS also determined that the remainder of the proposed species do not warrant listing as endangered or threatened species, and three proposed species (proposed October 2013) are not determinable under the ESA. Listed species that could occur in the MITT Study Area are highlighted in Table 3.8-1 and detailed below.

Table 3.8-1: Endangered Species Act Listing Determinations for Species Potentially within the Mariana Islands Training and Testing Study Area

Species Names				
Family	**Common Name**	**Scientific Name**	**Threatened/ Endangered[3]**	**Occurrence[4]**
Acroporidae	Bottlebrush staghorn	*Acropora aculeus*[1,2]		Common
	Fuzzy table coral	*Acropora paniculata*[2]		Rare
	Blue-tipped staghorn	*Acropora acuminata*[1,2]		Uncommon
	Staghorn coral	*Acropora aspera*[1,2]		Common
		***Acropora globiceps*[2]**	Threatened	Common
		Acropora listeri[2]		Uncommon
		Acropora microclados		Uncommon
		Acropora palmerae[1,2]		Uncommon
		Acropora paniculata[2]		Rare
		Acropora polystoma		Uncommon
		Acropora retusa	Threatened	Rare[5]
		Acropora striata[1,2]		Rare
		***Acropora tenella*[2]**	Threatened	Common
		Acropora vaughani[1,2]		Uncommon
		Acropora verweyi[1,2]		Common/Locally abundant
		Anacropora puertogalerae[2]		Uncommon
		Astreopora cucullata		Rare[5]
		Isopora cuneata[1,2]		Common
	Pore coral	*Montipora caliculata*[1,2]		Uncommon
		Montipora lobulata[1,2]		Rare
		Montipora patula		Rare
		Montipora turgescens		Rare[5]

Table 3.8-1: Endangered Species Act Listing Determinations for Species Potentially within the Mariana Islands Training and Testing Study Area (continued)

Species Names				
Family	**Common Name**	**Scientific Name**	**Proposed Threatened/ Endangered**	**Occurrence**
Agariciidae	Rugosa coral	*Pachyseris rugosa*[2]		Common
Euphyllidae	Grape coral	*Euphyllia cristata*[1,2]		Uncommon
		Euphyllia paraancora[2]		Uncommon
		Physogyra lichtensteini[2]		Common
Faviidae	Faviid coral	*Barabattoia laddi*[2]		Rare
Milleporidae	Fire coral	*Millepora foveolata*[1]		Rare
		Millepora tuberosa[1,2]		Rare
Mussidae	Starry cup coral	*Acanthastrea brevis*[2]		Uncommon
		Acanthastrea ishigakiensis[2]		Uncommon
		Acanthastrea regularis[2]		Uncommon
Pectinidae	Lettuce coral	*Pectinia alcicornis*[2]		Uncommon
Pocilloporidae	Cauliflower coral	*Pocillopora danae*[1]		Uncommon
		Pocillopora elegans (Indo-Pacific)[1,2]		Common
	Bird nest coral	***Seriatopora aculeata***[1,2]	Threatened	Uncommon
Poritidae	Net coral	*Alveopora allingi*[1,2]		Uncommon
		Alveopora fenestrata[1,2]		Uncommon
		Alveopora verrilliana[1,2]		Uncommon
	Hump coral	*Porites horizontalata*[1,2]		Common
		Porites nigrescens[2]		Common

[1] Randall 2003
[2] Center for Biological Diversity 2009
[3] Threatened/Endangered listings were based on the final listing determination in 79 FR 53851.
[4] Brainard et al. 2011; Occurrence is based on a relative abundance scale that ranges from Dominant, Common, Occasional or Uncommon, to Rare, with the largest abundance present on the dominant side of the scale and least abundance present on the rare side of the scale.
[5] National Marine Fisheries Service 2012.
[6] The coral *Montipora turgescens* itself is not a petitioned species, but was proposed as a threatened coral clade, *M. dilatata/flabellata/turgescens*.
[7] *Pocillipora elegans* is treated as two regional populations in the proposed listing: *P. elegans* (Indo-Pacific) and *P. elegans* (Eastern Pacific). Only the Indo-Pacific regional population is proposed as “threatened.”

3.8.1.1.1 *Acropora globiceps* (Staghorn Coral)

3.8.1.1.1.1 Status and Management

In December 2012, NMFS issued a proposed rule for reef-building coral species, including a proposed listing for the staghorn coral (*Acropora globiceps*) as threatened (77 FR 73220–73262). NMFS has not proposed a critical habitat designation. The proposed listing was based on a comprehensive status review (Brainard et al. 2011), a summary of management and conservation measures, and a supplemental information report addressing new information and public comment to both status and management reports (National Marine Fisheries Service 2012). NMFS reviewed the status of this species and efforts being made to protect the species, as well as public comments received on the proposed rule, and made determinations based on the best scientific and commercial data available. In September 2014, NMFS published a Final Rule (79 FR 53851), which concluded that this species warranted listing as threatened under the ESA. NMFS is currently soliciting information that may be relevant to the designation of critical habitat for this species.

3.8.1.1.1.2 Habitat and Geographic Range

Acropora globiceps has been reported from the central Indo-Pacific, the oceanic west Pacific, and the central Pacific (Richards et al. 2008a). It has been reported as common and relatively widespread longitudinally but restricted latitudinally and has a narrow depth range. *Acropora globiceps* has been reported from intertidal, upper reef slopes, and reef flats (Australian Institute of Marine Science 2010) and has been reported in water depths ranging from 0 to 8 m (0 to 26.2 ft.).

3.8.1.1.1.3 Population and Abundance

Within its range, *Acropora globiceps* has been reported as common (Australian Institute of Marine Science 2010).

3.8.1.1.1.4 Predator-Prey Interactions

The specific effects of predation are poorly known for *Acropora globiceps*. However, most acroporid corals are preferentially consumed by crown-of-thorns seastars (*Acanthaster planci*) and by corallivorous snails.

3.8.1.1.1.5 Species-Specific Threats

Acroporia globiceps is susceptible to the same suite of stressors that generally threaten corals. NMFS evaluated the population's demographic, spatial structure, and vulnerability factors (77 FR 73220–73262). Elements that contributed to *A. globiceps* threatened status were high vulnerability to ocean warming, moderate vulnerability to disease and acidification, trophic effects of fishing, nutrients, and predation as well as narrow overall distribution (based on shallow depth distribution (79 FR 53851).

3.8.1.1.2 *Acropora retusa* (Staghorn Coral)

3.8.1.1.2.1 Status and Management

In December 2012, NMFS issued a proposed rule for reef-building coral species, including a proposed listing for the staghorn coral (*Acropora retusa*) as threatened (77 FR 73220–73262). NMFS has not proposed a critical habitat designation. The proposed listing was based on a comprehensive status review (Brainard et al. 2011), a summary of management and conservation measures, and a supplemental information report addressing new information and public comment to both status and management reports (National Marine Fisheries Service 2012). NMFS reviewed the status of this species and efforts being made to protect the species, as well as public comments received on the proposed rule, and made determinations based on the best scientific and commercial data available. In September 2014, NMFS published a Final Rule (79 FR 53851), which concluded that this species warranted listing as threatened under the ESA. NMFS is currently soliciting information that may be relevant to the designation of critical habitat for this species.

3.8.1.1.2.2 Habitat and Geographic Range

Acropora retusa has been reported in the southwest and northern Indian Ocean, the central Indo-Pacific, the Solomons, the oceanic west Pacific, and the central Pacific (Richards et al. 2008e). *A. retusa* has been reported to occur in shallow, tropical reef environments and on upper reef slopes and in tidal pools from 1 to 5 m (3.3 to 16.4 ft.). *A. retusa* has a widespread distribution longitudinally but is restricted latitudinally (Brainard et al. 2011). This species is not known to occur in waters off Guam and the CNMI (Brainard et al. 2011).

3.8.1.1.2.3 Population and Abundance

Acropora retusa has only been reported in the waters off Guam and is rare in the Study Area (HDR 2011).

3.8.1.1.2.4 Predator-Prey Interactions

The specific effects of predation are poorly known for *Acropora retusa.* However, most acroporid corals are preferentially consumed by crown-of-thorns seastars (*Acanthaster planci)* and by corallivorous snails.

3.8.1.1.2.5 Species-Specific Threats

Acroporia retusa is susceptible to the same suite of stressors that generally threaten corals. NMFS evaluated the population's demographic, spatial structure, and vulnerability factors (77 FR 73220–73262). In the proposed rule using the listing determination tool approach, *A. retusa* was proposed for listing as threatened because of high vulnerability to ocean warming, moderate vulnerability to disease and acidification, uncommon generalized rangewide abundance, moderate overall distribution (based on wide geographic distribution and shallow depth distribution), and inadequacy of existing regulatory mechanisms. In the final listing (79 FR 53851), NMFS determined that the species warranted listing as threatened because *A. retusa* is highly susceptible to ocean warming; disease; ocean acidification; trophic effects of fishing, predation, and nutrients; a shallow habitat restriction; and overall rare abundance.

3.8.1.1.3 *Acropora tenella* (Staghorn Coral)

3.8.1.1.3.1 Status and Management

In December 2012, NMFS issued a proposed rule for reef-building coral species, including a proposed listing for the staghorn coral (*Acropora tenella*) as threatened (77 FR 73220–73262). NMFS has not proposed a critical habitat designation. The proposed listing was based on a comprehensive status review (Brainard et al. 2011), a summary of management and conservation measures, and a supplemental information report addressing new information and public comment to both status and management reports (National Marine Fisheries Service 2012). NMFS reviewed the status of this species and efforts being made to protect the species, as well as public comments received on the proposed rule, and made determinations based on the best scientific and commercial data available. In September 2014, NMFS published a Final Rule (79 FR 53851), which concluded that this species warranted listing as threatened under the ESA. NMFS is currently soliciting information that may be relevant to the designation of critical habitat for this species.

3.8.1.1.3.2 Habitat and Geographic Range

Acropora tenella has been reported to have a moderately broad range overall, from the central Indo-Pacific, Japan, the East China Sea, and Southeast Asia, and includes the Mariana Islands (Aeby et al. 2008).

Acropora tenella has been reported to occupy lower slopes below 40 m (131.2 ft.), protected slopes and shelves as deep as 70 m (229.7 ft.), apparently specialized to calm, deep conditions in water depths ranging from 25 to 70 m (82.0 to 229.7 ft.). *Acropora tenella* is known primarily from mesophotic habitats, suggesting the potential for deep refugia.

3.8.1.1.3.3 Population and Abundance

Abundance of *Acropora tenella* has been reported as locally common in some locations (Australian Institute of Marine Science 2010).

3.8.1.1.3.4 Predator-Prey Interactions

The specific effects of predation are poorly known for *Acropora tenella*. Most Acropora are preferentially consumed by crown-of-thorns seastars (*Acanthaster planci*) and by corallivorous snails.

3.8.1.1.3.5 Species-Specific Threats

Acroporia tenella is susceptible to the same suite of stressors that generally threaten corals. NMFS evaluated the population's demographic, spatial structure, and vulnerability factors (77 FR 73220–73262) and identified elements that contributed to *A. tenella* proposed threatened status. These were a high vulnerability to ocean warming, moderate vulnerability to disease and acidification, uncommon generalized rangewide abundance, wide overall distribution (based on moderate geographic distribution and wide depth distribution), and inadequacy of existing regulatory mechanisms. In the final listing (79 FR 53851), NMFS determined that the species warranted listing as threatened because *A. tenella* is highly susceptible to ocean warming; disease; ocean acidification; trophic effects of fishing, predation, and nutrients; geographic restriction; and overall population size.

3.8.1.1.4 *Seriatopora aculeata* (Bird Nest Coral)

3.8.1.1.4.1 Status and Management

In December 2012, NMFS issued a proposed rule for reef-building coral species, including a proposed listing for the bird nest coral (*Seriatopora aculeata*) as threatened (77 FR 73220–73262). NMFS has not proposed a critical habitat designation. The proposed listing was based on a comprehensive status review (Brainard et al. 2011), a summary of management and conservation measures, and a supplemental information report addressing new information and public comment to both status and management reports (National Marine Fisheries Service 2012). NMFS reviewed the status of this species and efforts being made to protect the species, as well as public comments received on the proposed rule, and made determinations based on the best scientific and commercial data available. In September 2014, NMFS published a Final Rule (79 FR 53851), which concluded that this species warranted listing as threatened under the ESA. NMFS is currently soliciting information that may be relevant to the designation of critical habitat for this species.

3.8.1.1.4.2 Habitat and Geographic Range

Seriatopora aculeata has a relatively confined distribution. It has been reported primarily from the Indo-Pacific, including Australia, Fiji, Indonesia, Japan, and Papua New Guinea. According to the International Union for Conservation of Nature and Natural Resources Species Account, *Seriatopora aculeata* has been recorded in the Northern Mariana Islands (Hoeksema et al. 2008e).

Seriatopora aculeata has been reported to occupy shallow reef environments in water depths ranging from 3 to 40 m (9.8 to 131.2 ft.).

3.8.1.1.4.3 Population and Abundance

Abundance of *Seriatopora aculeata* has been reported as uncommon (Australian Institute of Marine Science 2010).

3.8.1.1.4.4 Predator-Prey Interactions

The specific effects of predation are poorly known for *Seriatopora aculeata*. The genus Seriatopora is known to be susceptible to predation by snails and the crown-of-thorns seastar (*Acanthaster planci*).

3.8.1.1.4.5 Species-Specific Threats

Seriatopora aculeata is susceptible to the same suite of stressors that generally threaten corals. NMFS evaluated the population's demographic, spatial structure, and vulnerability factors (77 FR 73220–73262) and identified elements that contributed to the proposed listing status of *Seriatopora aculeata*. These elements included high vulnerability to ocean warming, moderate vulnerability to disease and acidification, uncommon generalized rangewide abundance, moderate overall distribution (based on moderate geographic distribution and moderate depth distribution), and inadequacy of existing regulatory mechanisms. In the final listing (79 FR 53851), NMFS determined that the species warranted listing as threatened because *S. aculeata* is highly susceptible to ocean warming; disease; ocean acidification; trophic effects of fishing, nutrients, and collection and trade; inadequate regulatory mechanisms; and geographic restriction.

3.8.1.1.4.6 Taxonomic Groups

All marine invertebrate species groups are represented in the Study Area. Paulay (2003a) presents an overview of the marine biodiversity of Guam, which has the best documented marine biota in Micronesia. Of all the species noted in the marine biodiversity survey of Guam (which included chordates, protists [mostly unicellular organisms], and algae species), it was found that seven major invertebrate species groups (Table 3.8-2) comprise approximately 65 percent of the species observed (Paulay 2003a) (Figure 3.8-1). Throughout the marine invertebrate section, organisms will often be referred to by their phylum name, or more generally, as marine invertebrates.

Table 3.8-2: Major Taxonomic Groups of Marine Invertebrates in the Mariana Islands Training and Testing Study Area

Major Invertebrate Groups[1]		Presence in Study Area	
Common Name (Phylum)	**Description**	**Open Ocean**	**Coastal Waters**
Cephalopods, bivalves, sea snails, chitons (Mollusca)	Benthic and planktonic predators, filter feeders, and grazers, with a muscular foot and in some groups a ribbon-like band of teeth used to scrape food off rocks	Water column, seafloor	Water column, seafloor
Shrimp, crabs, lobsters, barnacles, copepods (Arthropoda Subphylum Crustacea)	Benthic and planktonic predators, filter feeders with segmented bodies and external skeletons with jointed appendages	Water column, seafloor	Water column, seafloor
Corals, hydroids, jellyfish (Cnidaria)	Benthic and planktonic animals with stinging cells; sessile corals are main builders of coral reef frameworks	Water column, seafloor	Water column, seafloor
Sea stars, sea urchins, sea cucumbers (Echinodermata)	Benthic and planktonic (during larval phase) predators, filter feeders with tube feet.	Seafloor	Seafloor
Segmented worms (Annelida)	Mostly benthic, highly mobile marine worms, many tube-dwelling species	Seafloor	Seafloor
Sponges (Porifera)	Mostly benthic animals; sessile filter feeders, large species have calcium carbonate or silica spicules or bodies embedded in cells to provide structural support	Water column, seafloor	Water column, seafloor

Table 3.8-2: Major Taxonomic Groups of Marine Invertebrates in the Mariana Islands Training and Testing Study Area (continued)

Major Invertebrate Groups[1]		Presence in Study Area	
Common Name (Phylum)	**Description**	**Open Ocean**	**Coastal Waters**
Flatworms (Platyhelminthes)	Mostly benthic, simplest form of marine worm with a flattened body	Water column, seafloor	Water column, seafloor
Ribbon worms (Nemertea)	Benthic marine worms with long extension (proboscis) from the mouth that helps capture food	Water column, seafloor	Seafloor
Round worms (Nematoda)	Small benthic marine worms, many live in close association with other animals (parasitic)	Water column, seafloor	Water column, seafloor
Foraminifera, radiolarians, ciliates (Kingdom Protozoa)	Benthic and planktonic single-celled organisms; shells typically made of calcium carbonate or silica	Water column, seafloor	Water column, seafloor

[1] Major invertebrate groups are based on Marine Diversity of Guam (Paulay 2003a) and Catalogue of Life (Bisby et al. 2010).
[2] Other invertebrate groups are represented in the "Other Taxa" category of Paulay (2003a).
Notes: Benthic = A bottom-dwelling organism, Planktonic = An organism (or life stage of an organism) that drifts in open ocean environments.

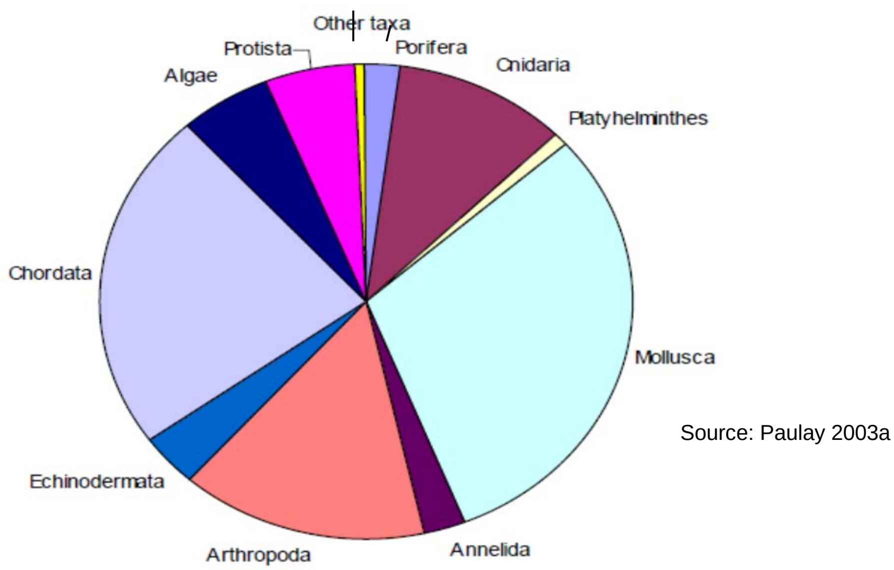


Figure 3.8-1: Diversity of Phylogenetic Groups in the Mariana Islands

3.8.2 AFFECTED ENVIRONMENT

Marine invertebrates live in the world's oceans, from warm-shallow waters to cold-deep waters. They inhabit the seafloor and water column in all of the large marine ecosystems and open-ocean areas in the Study Area. Marine invertebrate distribution in the Study Area is influenced by habitat, ocean currents, physical and water chemistry factors such as temperature, salinity and nutrient content (Levinton 2009). The distribution of invertebrates is also influenced by their distance from the equator (latitude); in general, the number of marine invertebrate species increases toward the equator (Macpherson 2002). The higher number of species (diversity) and abundance of marine invertebrates in coastal habitats, compared with the open ocean, is a result of the food and protection that coastal habitats provide (Levinton 2009).

The Mariana nearshore environment is characterized by extensive coral bottom and coral reef areas. The Mariana coral reefs differ between the northern and southern island groups, northern islands having lower coral diversity and colony surface area than southern islands; however, coral densities are similar between the groups (Randall 2003; Abraham et al. 2004; Chin et al. 2011). There is also a greater species diversity of fishes and molluscs (invertebrates) in waters around the southern islands than around the northern islands. For example, Guam has diverse invertebrate assemblages, known species include 59 flatworms, 1,722 molluscs, 104 polychaetes, 840 arthropods, and 196 echinoderm species (Abraham et al. 2004; Burdick et al. 2008).

In general, the coral reefs of the Marianas have a lower coral diversity compared to other reefs in the northwestern Pacific (e.g., Palau, Philippines, Australian Great Barrier Reef, southern Japan, and Marshall Islands) but a higher diversity than the reefs of Hawaii. Corals reported in Guam are typically found on shallow reefs and upper forereefs (or outer portion of the reef, closest to open ocean) at depths less than 245 feet (ft.) (74.7 meters [m]), and deeper forereef habitats within the photic zone that allows for coral growth (greater than 245 ft. [greater than 74.7 m] water depth) (Randall 2003).

On the island of Guam, most northern shorelines are karstic (layer or layers of soluble bedrock, usually carbonate rock such as limestone or dolomite) and bordered by limestone cliffs. In a few areas, the shorelines consist of volcanic substrates. On windward shores, reefs are narrow and have steep forereefs. Narrow reef flats or shallow fringing reefs (approximately 325–3,250 ft. [99.06–990.6 m] wide) are characteristic of leeward and more protected coastlines. Reefs also occur in lagoonal habitats in Apra Harbor and Cocos Lagoon. Reef organisms also occur on eroded limestone substrates including submerged caves and crevices, and large limestone blocks fallen from shoreline cliffs (Paulay 2003b).

3.8.2.1 Invertebrate Hearing and Vocalization

Very little is known about sound detection and use of sound by aquatic invertebrates (Budelmann 2010; Montgomery et al. 2006; Popper et al. 2001). 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 function like the fish swim bladder in responding to pressure (Budelmann 2010; Popper et al. 2001). Many aquatic invertebrates, however, have ciliated “hair” cells that may be sensitive to water movements, such as those caused by currents or water particle motion very close to a sound source (Budelmann 2010; Mackie and Singla 2003). These cilia may allow invertebrates to sense nearby prey or predators or help with local navigation.

Aquatic invertebrates that can sense local water movements with ciliated cells include cnidarians, flatworms, segmented worms, urochordates (tunicates), molluscs, and arthropods (Budelmann 2010; Popper et al. 2001). The sensory capabilities of corals are largely limited to detecting water movement using receptors on their tentacles (Gochfeld 2004), and the exterior cilia of coral larvae likely help them detect nearby water movements (Vermeij et al. 2010). Some aquatic invertebrates have specialized organs called statocysts for the determination of equilibrium and, in some cases, linear or angular acceleration. Statocysts allow an animal to sense movement, and may enable some species, such as cephalopods and crustaceans, to be sensitive to water particle movements associated with sound (Hu et al. 2009; Kaifu et al. 2008; Montgomery et al. 2006; Popper et al. 2001). Because any acoustic sensory capabilities, if present at all, are limited to detecting water motion, and 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.

Both behavioral and auditory brainstem response studies suggest that crustaceans may sense sounds up to 3 kilohertz (kHz), but best sensitivity is likely below 200 Hertz (Hz) (Lovell et al. 2005; Lovell et al. 2006). Most cephalopods (e.g., octopus and squid) likely sense low-frequency sound below 1,000 Hz, with best sensitivities at lower frequencies (Budelmann 2010; Mooney et al. 2010; Packard et al. 1990). A few cephalopods may sense higher frequencies up to 1,500 Hz (Hu et al. 2009). Squid did not respond to toothed whale ultrasonic echolocation clicks at peak sound pressure levels ranging from 199 to 226 decibels (dB) referenced to (re) 1 micropascal (μPa), likely because these clicks were outside of squid hearing range (Wilson et al. 2007). However, squid exhibited alarm responses when exposed to broadband sound from an approaching seismic airgun with received levels exceeding 145 to 150 dB re 1 micropascal squared second (μPa^2-s) root mean square (McCauley et al. 2000b). Four species of cephalopods showed damage to statocysts following exposure to a swept sine waveform (50 to 400 Hz) repeated every second for 2 hours with a peak of 175 dB re 1 μPa (Andre et al. 2011).

Aquatic invertebrates may produce and use sound in territorial behavior, to deter predators, to find a mate, and to pursue courtship (Popper et al. 2001). Some crustaceans, such as lobsters and snapping shrimp, produce sound by rubbing or closing hard body parts together (Latha et al. 2005; Patek and Caldwell 2006). The snapping shrimp chorus makes up a significant portion of the ambient noise budget in many locales (Cato and Bell 1992). Each click is up to 215 dB re 1 μPa, with a peak around 2 to 5 kHz (Heberholz and Schmitz 2001). Other crustaceans make low-frequency rasping or rumbling noises, perhaps used in defense or territorial display, that are often obscured by ambient noise (Patek and Caldwell 2006; Patek et al. 2009).

Reef noises, such as fish pops and grunts, sea urchin and parrotfish grazing (around 1.0 kHz to 1.2 kHz), and snapping shrimp noises (around 5 kHz) (Radford et al. 2010), may be used as a cue by some aquatic invertebrates. Nearby reef noises were observed to affect movements and settlement behavior of coral and crab larvae (Jeffs et al. 2003; Radford et al. 2007; Stanley et al. 2010; Vermeij et al. 2010). Larvae of other crustacean species, including pelagic and nocturnally emergent species that benefit from avoiding coral reef predators, appear to avoid reef noises (Simpson et al. 2011). Detection of reef noises is likely limited to short distances (less than 330 ft. [100 m]) (Vermeij et al. 2010).

3.8.2.2 General Threats

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). Coral reefs can be stressed or damaged by coastal development (Risk 2009), impacts from inland pollution and erosion (Cortes and Risk 1985), overexploitation and destructive fishing practices (Jackson et al. 2001, Pandolfi et al. 2003), global climate change and acidification (Hughes et al. 2003), disease (Porter et al. 2001), predation, harvesting by the aquarium trade (Caribbean Fishery Management Council 1994), anchors (Burke and Maidens 2004), invasive species (Bryant et al. 1998; Galloway et al. 2009, National Marine Fisheries Service 2010a; Wilkinson 2002), ship groundings (National Oceanic and Atmospheric Administration 2010b), oil spills (National Oceanic and Atmospheric Administration 2010b), and possibly human-made noise (Brainard et al. 2011, Vermeij et al. 2010).

The reefs near populated areas Guam, Saipan, Tinian, and Rota receive most of the human impacts from coastal development, population growth, fishing, and tourism. These threats can result in coral death from coastal runoff (Downs et al. 2009), reduced growth rates caused by a decrease in the pH of the ocean from pollution (Cohen et al. 2009), reduced tolerance to global climate change (Carilli et al. 2010), and increased susceptibility to bleaching (which are often tied to atypically high sea temperatures [Brown 1997; Glynn 1993; van Oppen and Lough 2009]). Human-made noise may impact coral larvae by masking the natural sounds that serve as cues to orient them towards suitable settlement sites (Vermeij et al. 2010).

Exposure to runoff from land from development projects can also affect local reef communities. Erosion rates in the Ugum Watershed on Guam doubled from 1975 to 1993 as a result of road construction and development projects. The discharge of cleaning chemicals has also occurred, with subsequent impacts on local coral populations (Wilkinson 2002). Exposure to oil runoff from land, and natural seepage is another threat to marine invertebrates. Additional information on the biology, life history, and conservation of marine invertebrates (ESA-listed species, species of concern, and candidate species) can be found on the website maintained by the National Marine Fisheries Service.

The discussion above represents general threats to marine invertebrates. Additional threats to individual species within the Study Area are described below in the accounts of those species. The following sections include descriptions of species not warranted to be listed as threatened or endangered under the ESA, and descriptions of the major marine invertebrate taxonomic groups in the Study Area. The species-specific information emphasizes the ESA-listed and candidate species because any threats to or potential impacts on those species are subject to consultation with regulatory agencies.

The ESA process for the 66 species of reef-building corals proposed for listing (originally petitioned by the Center for Biological Diversity [Sakashita and Wolf 2009]) is the broadest and most complex listing process undertaken by NMFS (Brainard et al. 2011). A rigorous threat evaluation was developed for these corals, and 19 key threats were selected as the most important factors influencing the potential extinction of candidate coral species before the year 2100 (Table 3.8-3). Because most of these threats are also known to generally affect marine invertebrate groups, the information is presented here in General Threats rather than within a subsequent subsection.

Table 3.8-3: Summary of Proximate Threats to Coral Species

Proximate Threat[1]	Importance	Used in Coral ESA Determinations
Ocean Warming	High	Yes
Disease	High	Yes
Ocean Acidification	Med-High	Yes
Reef Fishing – Trophic Effects	Medium	Yes
Sedimentation	Low-Medium	Yes
Nutrients	Low-Medium	Yes
Sea-Level Rise	Low-Medium	Yes
Toxins	Low	No
Changing Ocean Circulation	Low	No
Changing Storm Tracks/Intensities	Low	No
Predation	Low	Yes
Reef Fishing – Habitat Impacts/Destructive Fishing Practices	Low	No
Ornamental Trade	Low	Yes
Natural Physical Damage	Low	No
Human-induced Physical Damage	Negligible-Low	No
Aquatic Invasive Species	Negligible-Low	No

Table 3.8-3: summary of Proximate Threats to Coral Species (continued)

Proximate Threat[1]	Importance	Used in Coral ESA Determinations
Salinity	Negligible	No
African/Asian Dust	Negligible	No
Changes in Insolation	Probably Negligible	No

[1] As summarized by Brainard et al. (2011). The authors note that, accepting "natural physical damage" and "changes in insolation," the ultimate factor for all of the proximate threats is growth in human population and consumption of natural resources.

Note: ESA = Endangered Species Act

3.8.2.3 Coral Species Not Warranting ESA Listing

3.8.2.3.1 *Acropora aculeus* (Bottlebrush Coral)

3.8.2.3.1.1 Status and Management

In December 2012, NMFS issued a proposed rule for reef-building coral species, including a proposed listing for bottlebrush coral (*Acropora aculeus*) as threatened (77 FR 73220–73262). The proposed listing was based on a comprehensive status review (Brainard et al. 2011), a summary of management and conservation measures, and a supplemental information report addressing new information and public comment to both status and management reports (National Marine Fisheries Service 2012). NMFS reviewed the status of this species and efforts being made to protect the species, as well as public comments received on the proposed rule, and made determinations based on the best scientific and commercial data available. In September 2014, NMFS published a Final Rule (79 FR 53851), which concluded that this species did not warrant listing as endangered or threatened under the ESA.

3.8.2.3.1.2 Habitat and Geographic Range

Acroporid corals (the largest group of stony corals) are typically found in shallow, warm, nutrient-poor waters that allow sufficient sunlight penetration to support photosynthesis by zooxanthellae, single-cell algae hosted by the coral. Throughout its range, Acroporid corals can be found on any stretch of reef and is often the dominant coral, especially along the reef front. Staghorn and plate forms flourish in sheltered areas, whereas clusters and semi-massive types can withstand more exposed conditions.

Acropora aculeus has a broad depth range. It is particularly abundant in shallow lagoons and is common in most habitats where it is protected from direct wave action. *Acropora aculeus* has been reported in water depths ranging from low tide to at least 20 m (65.6 ft.) (Brainard et al. 2011).

Acropora aculeus has a relatively broad range, extending from east Africa, the Comorros, and Seychelles in the Indian Ocean all the way to Pitcairn Island in the southeastern Pacific Ocean. Latitudinally, it has been reported from Japanese waters in the northern hemisphere across the southern Great Barrier Reef and Mozambique in the southern hemisphere. According to both the International Union for Conservation of Nature and Natural Resources Species Account and the Convention on International Trade in Endangered Species database, *Acropora aculeus* occurs in American Samoa, the Northern Mariana Islands, and the United States (U.S.) minor outlying islands (Brainard et al. 2011).

3.8.2.3.1.3 Population and Abundance

Abundance of *Acropora aculeus* has been reported as generally common and locally abundant, especially in the central Indo-Pacific (Australian Institute of Marine Science 2010).

3.8.2.3.1.4 Predator-Prey Interactions

Most species from the Acroporidae family are preferentially consumed by crown-of-thorns seastars (*Acanthaster planci*) and by corallivorous snails.

3.8.2.3.1.5 Species-Specific Threats

Bottlebrush coral has no species-specific threats. It is susceptible to the same suite of stressors that generally threaten corals. NMFS evaluated the population's demographic, spatial structure, and vulnerability factors and identified elements that threaten *Acropora aculeus.* These elements include high vulnerability to ocean warming, moderate vulnerability to disease and acidification, common generalized rangewide abundance, wide overall distribution (based on wide geographic distribution and moderate depth distribution), and inadequacy of existing regulatory mechanisms (79 FR 53851).

3.8.2.3.2 *Acropora paniculata* (Fuzzy Table Coral)

3.8.2.3.2.1 Status and Management

In December 2012, NMFS issued a proposed rule for reef-building coral species, including a proposed listing for fuzzy table coral (*Acropora paniculata*) as threatened (77 FR 73220–73262). NMFS has not proposed a critical habitat designation. The proposed listing was based on a comprehensive status review (Brainard et al. 2011), a summary of management and conservation measures, and a supplemental information report addressing new information and public comment to both status and management reports. Additional information regarding this coral species, including the Petition to List 82 Coral Species Under the ESA by the Center for Biological Diversity (Sakashita and Wolf 2009), can be accessed at the website maintained by the NMFS Office of Protected Resources. NMFS reviewed the status of this species and efforts being made to protect the species, as well as public comments received on the proposed rule, and made determinations based on the best scientific and commercial data available. In September 2014, NMFS published a Final Rule (79 FR 53851), which concluded that this species did not warrant listing as endangered or threatened under the ESA.

3.8.2.3.2.2 Habitat and Geographic Range

Acropora paniculata has been reported to occupy upper reef slopes, just subtidal, reef edges, and sheltered lagoons in water depths ranging from 10 to 35 m (32.8 to 114.8 ft.) (Brainard et al. 2011).

Acropora paniculata has been reported across a wide distribution ranging from the Red Sea and Indian Ocean to the west and central Pacific.

3.8.2.3.2.3 Population and Abundance

Abundance of *Acropora paniculata* has been reported as uncommon to rare on most reefs; however, the fuzzy table coral is common in Papua New Guinea (Australian Institute of Marine Science 2010, Wallace 1999, Brainard et al. 2011).

3.8.2.3.2.4 Predator-Prey Interactions

The specific effects of predation are poorly known for *Acropora paniculata*. Most species from the Acroporidae family are preferentially consumed by crown-of-thorns seastars (*Acanthaster planci*) and by corallivorous snails.

3.8.2.3.2.5 Species-Specific Threats

Acropora paniculata is susceptible to the same suite of stressors that generally threaten corals. NMFS evaluated the population's demographic, spatial structure, and vulnerability factors (77 FR 73220–73262) and identified elements that threaten *Acropora paniculata.* These elements included high vulnerability to ocean warming, moderate vulnerability to disease and acidification, uncommon generalized rangewide abundance, wide overall distribution (based on wide geographic distribution and moderate depth distribution), and inadequacy of existing regulatory mechanisms (79 FR 53851).

3.8.2.3.3 *Acropora acuminata* (Blue-Tipped Staghorn Coral)

3.8.2.3.3.1 Status and Management

In December 2012, NMFS issued a proposed rule for reef-building coral species, including a proposed listing for blue-tipped staghorn coral (*Acropora acuminata*) as threatened (77 FR 73220–73262). NMFS has not proposed a critical habitat designation. The proposed listing was based on a comprehensive status review (Brainard et al. 2011), a summary of management and conservation measures, and a supplemental information report addressing new information and public comment to both status and management reports (National Marine Fisheries Service 2012). NMFS reviewed the status of this species and efforts being made to protect the species, as well as public comments received on the proposed rule, and made determinations based on the best scientific and commercial data available. In September 2014, NMFS published a Final Rule (79 FR 53851), which concluded that this species did not warrant listing as endangered or threatened under the ESA.

3.8.2.3.3.2 Habitat and Geographic Range

Acropora acuminata has a very broad range, extending longitudinally from the Red Sea all the way to Pitcairn Island in the southeastern Pacific. It extends latitudinally from Taiwan in the northern hemisphere across the Great Barrier Reef in the southern hemisphere. It can be very common in the center of its range (e.g., Indonesia), but it can be uncommon in the outer parts of its range. Throughout its range, Acroporid corals can be found on any stretch of reef and is often the dominant coral, especially along the reef front where it has been reported in waters ranging from 15 to 20 m (49.2 to 65.6 ft.). Staghorn and plate forms flourish in sheltered areas, whereas clusters and semi-massive types can withstand more exposed conditions.

3.8.2.3.3.3 Population and Abundance

Acropora acuminata has been reported to occasionally live in extensive clumps with dimensions of several meters (Wallace 1999; Brainard et al. 2011).

3.8.2.3.3.4 Predator-Prey Interactions

Acropora acuminata is the only acroporid known to not be preferred as prey by the crown-of-thorns seastar. The crown-of-thorns seastar will eat *Acropora acuminata* if there are no other corals to prey on, but *Acropora acuminata are* among the last to be preyed upon.

3.8.2.3.3.5 Species-Specific Threats

Acropora acuminata is susceptible to the same suite of stressors that generally threaten corals. NMFS evaluated the population’s demographic, spatial structure, and vulnerability factors (77 FR 73220–73262) and identified elements that threaten *Acropora acuminata*. These elements include high vulnerability to ocean warming, moderate vulnerability to disease and acidification, uncommon generalized rangewide abundance, wide overall distribution (based on wide geographic distribution and moderate depth distribution), and inadequacy of existing regulatory mechanisms (79 FR 53851).

3.8.2.3.4 *Acropora aspera* (Staghorn Coral)

3.8.2.3.4.1 Status and Management

In December 2012, NMFS issued a proposed rule for reef-building coral species including a proposed listing for the staghorn coral (*Acropora aspera*) as threatened (77 FR 73220–73262). NMFS has not proposed a critical habitat designation. The proposed listing was based on a comprehensive status review (Brainard et al. 2011), a summary of management and conservation measures, and a supplemental information report addressing new information and public comment to both status and management reports (National Marine Fisheries Service 2012). NMFS reviewed the status of this species and efforts being made to protect the species, as well as public comments received on the proposed rule, and made determinations based on the best scientific and commercial data available. In September 2014, NMFS published a Final Rule (79 FR 53851), which concluded that this species did not warrant listing as endangered or threatened under the ESA.

3.8.2.3.4.2 Habitat and Geographic Range

Acropora aspera has been reported to occupy a broad range of habitats and its colony structure varies substantially with habitat and has been reported in water depths ranging from low tide to at least 10 m (32.8 ft.).

Acropora aspera has a relatively broad range, extending longitudinally from the Red Sea and Oman to Samoa (east central Pacific Ocean). It extends latitudinally from Japanese waters in the northern hemisphere across the Great Barrier Reef in the southern hemisphere. According to both the International Union for Conservation of Nature and Natural Resources Species Account and the Convention on International Trade in Endangered Species of Wild Fauna and Flora species database, *Acropora aspera* occurs in American Samoa, the Northern Mariana Islands, and the U.S. minor outlying islands.

3.8.2.3.4.3 Population and Abundance

Abundance of *Acropora aspera* has been reported as sometimes locally common (Australian Institute of Marine Science 2010). *Acropora aspera* can occasionally live in extensive clumps with dimensions of several meters.

3.8.2.3.4.4 Predator-Prey Interactions

Most Acropora are preferentially consumed by crown-of-thorns seastars (*Acanthaster planci*) and by corallivorous snails. *Acropora aspera* is a preferred prey of *Acanthaster planci* and, when killed, is rapidly overgrown by algae.

3.8.2.3.4.5 Species-Specific Threats

Acroporia aspera is susceptible to the same suite of stressors that generally threaten corals. NMFS evaluated the population’s demographic, spatial structure, and vulnerability factors (77 FR 73220–73262) and identified elements that threaten *Acropora aspera*. These elements include high vulnerability to ocean warming, moderate vulnerability to disease and acidification, common generalized rangewide abundance, narrow overall distribution (based on moderate geographic distribution and shallow depth distribution), and inadequacy of existing regulatory mechanisms (79 FR 53851).

3.8.2.3.5 *Acropora listeri* (Staghorn Coral)

3.8.2.3.5.1 Status and Management

In December 2012, NMFS issued a proposed rule for reef-building coral species, including a proposed listing for the staghorn coral (*Acropora listeri*) as threatened (77 FR 73220–73262). NMFS has not proposed a critical habitat designation. The proposed listing was based on a comprehensive status review (Brainard et al. 2011), a summary of management and conservation measures, and a supplemental information report addressing new information and public comment to both status and management reports (National Marine Fisheries Service 2012). NMFS reviewed the status of this species and efforts being made to protect the species, as well as public comments received on the proposed rule, and made determinations based on the best scientific and commercial data available. In September 2014, NMFS published a Final Rule (79 FR 53851), which concluded that this species did not warrant listing as endangered or threatened under the ESA.

3.8.2.3.5.2 Habitat and Geographic Range

Acropora listeri has been reported from the Red Sea, the northern Indian Ocean, the central Indo-Pacific, east and west coasts of Australia, Southeast Asia, Japan and the East China Sea, the oceanic west Pacific, and the central Pacific (Richards et al. 2008b). *Acropora listeri* has been reported from subtidal shallow reef edges, upper reef slopes, and in strong wave action in water depths ranging from near the surface to 15 m (49.2 ft.).

3.8.2.3.5.3 Population and Abundance

Abundance of *Acropora listeri* has been reported as uncommon (Australian Institute of Marine Science 2010).

3.8.2.3.5.4 Predator-Prey Interactions

The specific effects of predation are poorly known for *Acropora listeri*. However, most acroporid corals are preferentially consumed by crown-of-thorns seastars (*Acanthaster planci)* and by corallivorous snails.

3.8.2.3.5.5 Species-Specific Threats

Acroporia listeri is susceptible to the same suite of stressors that generally threaten corals. NMFS evaluated the population’s demographic, spatial structure, and vulnerability factors (77 FR 73220–73262) and identified elements that threaten *Acropora listeri*. These elements include high vulnerability to ocean warming, moderate vulnerability to disease and acidification, uncommon generalized rangewide abundance, overall moderate distribution (based on wide geographic distribution and shallow depth distribution), and inadequacy of existing regulatory mechanisms (79 FR 53851).

3.8.2.3.6 *Acropora microclados* (Staghorn Coral)

3.8.2.3.6.1 Status and Management

In December 2012, NMFS issued a proposed rule for reef-building coral species, including a proposed listing for the staghorn coral (*Acropora microclados*) as threatened (77 FR 73220–73262). NMFS has not proposed a critical habitat designation. The proposed listing was based on a comprehensive status review (Brainard et al. 2011), a summary of management and conservation measures, and a supplemental information report addressing new information and public comment to both status and management reports (National Marine Fisheries Service 2012). NMFS reviewed the status of this species and efforts being made to protect the species, as well as public comments received on the proposed rule, and made determinations based on the best scientific and commercial data available. In September 2014, NMFS published a Final Rule (79 FR 53851), which concluded that this species did not warrant listing as endangered or threatened under the ESA.

3.8.2.3.6.2 Habitat and Geographic Range

Acropora microclados has been reported from the Red Sea and the Gulf of Aden, the northern Indian Ocean, the central Indo-Pacific, Australia, Southeast Asia, Japan and the East China Sea, and the oceanic west Pacific (Richards et al. 2008c). *A. microclados* has been reported from upper reef slopes and subtidally at reef edges in water depths ranging from 5 to 20 m (16.4 to 65.6 ft.).

3.8.2.3.6.3 Population and Abundance

Abundance of *Acropora microclados* has been reported as uncommon (Australian Institute of Marine Science 2010; Veron and Wallace 1984).

3.8.2.3.6.4 Predator-Prey Interactions

The specific effects of predation are poorly known for *Acropora microclados*. However, most acroporid corals are preferentially consumed by crown-of-thorns seastars (*Acanthaster planci)* and by corallivorous snails.

3.8.2.3.6.5 Species-Specific Threats

Acroporia microclados is susceptible to the same suite of stressors that generally threaten corals. NMFS evaluated the population's demographic, spatial structure, and vulnerability factors (77 FR 73220–73262) and identified elements that may threaten *Acropora microclados*. These elements included high vulnerability to ocean warming, moderate vulnerability to disease and acidification, uncommon generalized rangewide abundance, wide overall distribution (based on wide geographic distribution and shallow depth distribution), and inadequacy of existing regulatory mechanisms (79 FR 53851).

3.8.2.3.7 *Acropora palmerae* (Staghorn Coral)

3.8.2.3.7.1 Status and Management

In December 2012, NMFS issued a proposed rule for reef-building coral species including a proposed listing for the staghorn coral (*Acropora palmerae*) as threatened (77 FR 73220–73262). NMFS has not proposed a critical habitat designation. The proposed listing was based on a comprehensive status review (Brainard et al. 2011), a summary of management and conservation measures, and a supplemental information report addressing new information and public comment to both status and management reports (National Marine Fisheries Service 2012). NMFS reviewed the status of this species and efforts being made to protect the species, as well as public comments received on the proposed rule, and made determinations based on the best scientific and commercial data available. In September 2014, NMFS published a Final Rule (79 FR 53851), which concluded that this species did not warrant listing as endangered or threatened under the ESA.

3.8.2.3.7.2 Habitat and Geographic Range

Acropora palmerae has been reported from the northern Indian Ocean, central Indo-Pacific, west and east coasts of Australia, Southeast Asia, Japan and the East China Sea, and the oceanic west Pacific.

Acropora palmerae has been reported to occupy reef flats exposed to strong wave action and lagoons and intertidal, subtidal, shallow, reef tops, reef flats, and reef edges in water depths ranging from 5 to 20 m (16.4 to 65.6 ft.).

3.8.2.3.7.3 Population and Abundance

Abundance of *Acropora palmerae* has been reported as uncommon (Australian Institute of Marine Science 2010; Carpenter et al. 2008).

3.8.2.3.7.4 Predator-Prey Interactions

The specific effects of predation are poorly known for *Acropora palmerae*. However, most acroporid corals are preferentially consumed by crown-of-thorns seastars (*Acanthaster planci*) and by corallivorous snails.

3.8.2.3.7.5 Species-Specific Threats

Acroporia palmerae is susceptible to the same suite of stressors that generally threaten corals. NMFS evaluated the population's demographic, spatial structure, and vulnerability factors (77 FR 73220–73262) and identified elements that may threaten *Acropora palmerae*. These elements included high vulnerability to ocean warming, moderate vulnerability to disease and acidification, uncommon generalized rangewide abundance, moderate overall distribution (based on moderate geographic distribution and moderate depth distribution), and inadequacy of existing regulatory mechanisms (79 FR 53851).

3.8.2.3.8 *Acropora polystoma* (Staghorn Coral)

3.8.2.3.8.1 Status and Management

In December 2012, NMFS issued a proposed rule for reef-building coral species, including a proposed listing for the staghorn coral (*Acropora polystoma*) as threatened (77 FR 73220–73262). NMFS has not proposed a critical habitat designation. The proposed listing was based on a comprehensive status review (Brainard et al. 2011), a summary of management and conservation measures, and a supplemental information report addressing new information and public comment to both status and management reports (National Marine Fisheries Service 2012). NMFS reviewed the status of this species and efforts being made to protect the species, as well as public comments received on the proposed rule, and made determinations based on the best scientific and commercial data available. In September 2014, NMFS published a Final Rule (79 FR 53851), which concluded that this species did not warrant listing as endangered or threatened under the ESA.

3.8.2.3.8.2 Habitat and Geographic Range

Acropora polystoma has been reported from the Red Sea and the Gulf of Aden, the south-west and northern Indian Ocean, the central Indo-Pacific, Australia, Southeast Asia, and the oceanic west Pacific (Richards et al. 2008d). *A. polystoma* has been reported from shallow, tropical reef environments. It is found on upper reef slopes exposed to strong wave action in water depths ranging from 3 to 10 m (9.8 to 32.8 ft.).

3.8.2.3.8.3 Population and Abundance

Abundance of *Acropora polystoma* has been reported as uncommon (Australian Institute of Marine Science 2010; Carpenter et al. 2008).

3.8.2.3.8.4 Predator-Prey Interactions

The specific effects of predation are poorly known for *Acropora polystoma*. However, most acroporid corals are preferentially consumed by crown-of-thorns seastars (*Acanthaster planci)* and by corallivorous snails.

3.8.2.3.8.5 Species-Specific Threats

Acroporia polystoma is susceptible to the same suite of stressors that generally threaten corals. NMFS evaluated the population's demographic, spatial structure, and vulnerability factors (77 FR 73220–73262) and identified elements that may threaten *Acropora polystoma*. These elements included high vulnerability to ocean warming, moderate vulnerability to disease and acidification, uncommon generalized rangewide abundance, moderate overall distribution (based on wide geographic distribution and shallow depth distribution), and inadequacy of existing regulatory mechanisms (79 FR 53851).

3.8.2.3.9 *Acropora striata* (Staghorn Coral)

3.8.2.3.9.1 Status and Management

In December 2012, NMFS issued a proposed rule for reef-building coral species, including a proposed listing for the staghorn coral (*Acropora striata*) as threatened (77 FR 73220–73262). NMFS has not proposed a critical habitat designation. The proposed listing was based on a comprehensive status review (Brainard et al. 2011), a summary of management and conservation measures, and a supplemental information report addressing new information and public comment to both status and management reports (National Marine Fisheries Service 2012). NMFS reviewed the status of this species and efforts being made to protect the species, as well as public comments received on the proposed rule, and made determinations based on the best scientific and commercial data available. In September 2014, NMFS published a Final Rule (79 FR 53851), which concluded that this species did not warrant listing as endangered or threatened under the ESA.

3.8.2.3.9.2 Habitat and Geographic Range

Acropora striata has been reported to have a moderately broad range overall. A search of published and unpublished records of occurrence in U.S. waters indicates *Acropora striata* has been reported from Ofu Lagoon in American Samoa, Guam (Randall 2003), Commonwealth of the Northern Mariana Islands, and Kingman Reef.

Acropora striata has been reported to occupy shallow rocky foreshores and shallow reef in water depths ranging from 10 to 25 m (32.8 to 82.0 ft.).

3.8.2.3.9.3 Population and Abundance

Abundance of *Acropora striata* has been reported as rare overall but may be locally dominant in some areas in Japan (Australian Institute of Marine Science 2010).

3.8.2.3.9.4 Predator-Prey Interactions

The specific effects of predation are poorly known for *Acropora striata*. Most Acropora are preferentially consumed by crown-of-thorns seastars (*Acanthaster planci*) and by corallivorous snails.

3.8.2.3.9.5 Species-Specific Threats

Acroporia striata is susceptible to the same suite of stressors that generally threaten corals. NMFS evaluated the population's demographic, spatial structure, and vulnerability factors (77 FR 73220–73262) and identified elements that may threaten *Acropora striata*. These elements included high vulnerability to ocean warming, moderate vulnerability to disease and acidification, uncommon generalized rangewide abundance, moderate overall distribution (based on moderate geographic distribution and moderate depth distribution), and inadequacy of existing regulatory mechanisms (79 FR 53851).

3.8.2.3.10 *Acropora vaughani* (Staghorn Coral)

3.8.2.3.10.1 Status and Management

In December 2012, NMFS issued a proposed rule for reef-building coral species including a proposed listing for the staghorn coral (*Acropora vaughani*) as threatened (77 FR 73220–73262). NMFS has not proposed a critical habitat designation. The proposed listing was based on a comprehensive status review (Brainard et al. 2011), a summary of management and conservation measures, and a supplemental information report addressing new information and public comment to both status and management reports (National Marine Fisheries Service 2012). NMFS reviewed the status of this species and efforts being made to protect the species, as well as public comments received on the proposed rule, and made determinations based on the best scientific and commercial data available. In September 2014, NMFS published a Final Rule (79 FR 53851), which concluded that this species did not warrant listing as endangered or threatened under the ESA.

3.8.2.3.10.2 Habitat and Geographic Range

Reported ranges of *Acropora vaughani* have been somewhat disjunct, with reports from Australia, the Red Sea, and southwest Indian Ocean. *Acropora v*aughani occurs in American Samoa and U.S. minor outlying islands, and also in the Northern Mariana Islands (Richards et al. 2008f).

Acropora vaughani has been reported to occupy fringing reefs with turbid water, protected lagoons and sandy slopes, or protected subtidal waters in water depths ranging from low tide levels to 30 m (98.4 ft.).

3.8.2.3.10.3 Population and Abundance

Abundance of *Acropora vaughani* has been reported as uncommon (Australian Institute of Marine Science 2010).

3.8.2.3.10.4 Predator-Prey Interactions

The specific effects of predation are poorly known for *Acropora vaughani*. Most Acropora are preferentially consumed by crown-of-thorns seastars (*Acanthaster planci*) and by corallivorous snails.

3.8.2.3.10.5 Species-Specific Threats

Acroporia vaughani is susceptible to the same suite of stressors that generally threaten corals. NMFS evaluated the population’s demographic, spatial structure, and vulnerability factors (77 FR 73220–73262) and identified elements that may threaten *Acropora vaughani*. These elements included high vulnerability to ocean warming, moderate vulnerability to disease and acidification, common generalized rangewide abundance, moderate overall distribution (based on wide geographic distribution and shallow depth distribution), and inadequacy of existing regulatory mechanisms (79 FR 53851).

3.8.2.3.11 *Acropora verweyi* (Staghorn Coral)

3.8.2.3.11.1 Status and Management

As In December 2012, NMFS issued a proposed rule for reef-building coral species including a proposed listing for the staghorn coral (*Acropora verweyi*) as threatened (77 FR 73220–73262). NMFS has not proposed a critical habitat designation. The proposed listing was based on a comprehensive status review (Brainard et al. 2011), a summary of management and conservation measures, and a supplemental information report addressing new information and public comment to both status and management reports (National Marine Fisheries Service 2012). NMFS reviewed the status of this species and efforts being made to protect the species, as well as public comments received on the proposed rule, and made determinations based on the best scientific and commercial data available. In September 2014, NMFS published a Final Rule (79 FR 53851), which concluded that this species did not warrant listing as endangered or threatened under the ESA.

3.8.2.3.11.2 Habitat and Geographic Range

Acropora verweyi has been reported to have a relatively broad range, extending from east Africa, the Comorros and Seychelles in the Indian Ocean all the way to Pitcairn Island in the southeastern Pacific Ocean which includes American Samoa and the Northern Mariana Islands (Richards et al. 2008g).

Acropora verweyi lives on upper reef slopes or other parts of the reef where circulation is good and has been reported to be an exclusively shallow-water species (Wallace 1999), living in depths ranging from low tide to at least 10 m (32.8 ft.).

3.8.2.3.11.3 Population and Abundance

Abundance of *Acropora verweyi* has been reported as generally common but can be locally abundant, especially in the western Indian Ocean (Australian Institute of Marine Science 2010).

3.8.2.3.11.4 Predator-Prey Interactions

The specific effects of predation are poorly known for *Acropora verweyi*. Most Acropora are preferentially consumed by crown-of-thorns seastars (*Acanthaster planci)* and by corallivorous snails.

3.8.2.3.11.5 Species-Specific Threats

Acroporia verweyi is susceptible to the same suite of stressors that generally threaten corals. NMFS evaluated the population's demographic, spatial structure, and vulnerability factors (77 FR 73220–73262) and identified elements that may threaten *Acropora verweyi*. These elements included high vulnerability to ocean warming, moderate vulnerability to disease and acidification; common generalized rangewide abundance, moderate overall distribution (based on wide geographic distribution and shallow depth distribution), and inadequacy of existing regulatory mechanisms (79 FR 53851).

3.8.2.3.12 *Anacropora puertogalerae* (Staghorn Coral)

3.8.2.3.12.1 Status and Management

In December 2012, NMFS issued a proposed rule for reef-building coral species including a proposed listing for the staghorn coral (*Anacropora puertogalerae*) as threatened (77 FR 73220–73262). NMFS has not proposed a critical habitat designation. The proposed listing was based on a comprehensive status review (Brainard et al. 2011), a summary of management and conservation measures, and a supplemental information report addressing new information and public comment to both status and management reports (National Marine Fisheries Service 2012). NMFS reviewed the status of this species and efforts being made to protect the species, as well as public comments received on the proposed rule, and made determinations based on the best scientific and commercial data available. In September 2014, NMFS published a Final Rule (79 FR 53851), which concluded that this species did not warrant listing as endangered or threatened under the ESA.

3.8.2.3.12.2 Habitat and Geographic Range

Anacropora puertogalerae has been reported throughout the Indo-Pacific, on the Great Barrier Reef in Australia, Fiji, Indonesia, Japan, and other areas. *Anacropora puertogalerae* has been reported to occur in the Northern Mariana Islands (Richards et al. 2008h).

Anacropora puertogalerae has been reported to occupy shallow reef environments in water depths ranging from 5 to 20 m (16.4 to 65.6 ft.), though it has also been found separated from reefs.

3.8.2.3.12.3 Population and Abundance

Abundance of *Anacropora puertogalerae* has been reported as uncommon but can form large thickets in the Philippines (Australian Institute of Marine Science 2010; International Union for Conservation of Nature 2013a).

3.8.2.3.12.4 Predator-Prey Interactions

Anacropora puertogalerae have been reported to be preyed on by wrasses, in proportion to availability. However, population-level effects remain unknown.

3.8.2.3.12.5 Species-Specific Threats

Anacropora puertogalerae is susceptible to the same suite of stressors that generally threaten corals. NMFS evaluated the population's demographic, spatial structure, and vulnerability factors (77 FR 73220–73262) and identified elements that may threaten *Anacropora puertogalerae*. These elements included high vulnerability to ocean warming, moderate vulnerability to disease and acidification, uncommon generalized rangewide abundance, moderate overall distribution (based on moderate geographic distribution and moderate depth distribution), and inadequacy of existing regulatory mechanisms (79 FR 53851).

3.8.2.3.13 *Astreopora cucullata* (Staghorn Coral)

3.8.2.3.13.1 Status and Management

In December 2012, NMFS issued a proposed rule for reef-building coral species, including a proposed listing for the staghorn coral (*Astreopora cucullata*) as endangered (77 FR 73220–73262). NMFS has not proposed a critical habitat designation. The proposed listing was based on a comprehensive status review (Brainard et al. 2011), a summary of management and conservation measures, and a supplemental information report addressing new information and public comment to both status and management reports (National Marine Fisheries Service 2012). NMFS reviewed the status of this species and efforts being made to protect the species, as well as public comments received on the proposed rule, and made determinations based on the best scientific and commercial data available. In September 2014, NMFS published a Final Rule (79 FR 53851), which concluded that this species did not warrant listing as endangered or threatened under the ESA.

3.8.2.3.13.2 Habitat and Geographic Range

Astreopora culcullata has been reported primarily in the Red Sea and Gulf of Aden, central Indo-Pacific, Southeast Asia, Eastern Australia, and oceanic west Pacific (Bass et al. 2008). *Astreopora cucullata* has been reported in protected reef environments in water depths ranging from 5 to 15 m.

3.8.2.3.13.3 Population and Abundance

Abundance of *Astreopora cucullata* has been reported as rare (Brainard et al. 2011) and has only been observed in waters off Guam (HDR 2011). Note that Brainard et al. (2011) does not list this species as occurring in waters off Guam and the CNMI.

3.8.2.3.13.4 Predator-Prey Interactions

The specific effects of predation are poorly known for *A. cucullata.*

3.8.2.3.13.5 Species-Specific Threats

Astreopora cucullata is susceptible to the same suite of stressors that generally threaten corals. NMFS evaluated the population's demographic, spatial structure, and vulnerability factors (77 FR 73220–73262) and identified elements that may threaten *Astreopora cucullata*. These elements included high vulnerability to ocean warming, moderate vulnerability to disease and acidification, uncommon generalized rangewide abundance, moderate overall distribution (based on wide geographic distribution and shallow depth distribution), and inadequacy of existing regulatory mechanisms (79 FR 53851).

3.8.2.3.14 *Isopora cuneata* (Staghorn Coral)

3.8.2.3.14.1 Status and Management

In December 2012, NMFS issued a proposed rule for reef-building coral species, including a proposed listing for the staghorn coral (*Isopora cuneata*) as threatened (77 FR 73220–73262). NMFS has not proposed a critical habitat designation. The proposed listing was based on a comprehensive status review (Brainard et al. 2011), a summary of management and conservation measures, and a supplemental information report addressing new information and public comment to both status and management reports (National Marine Fisheries Service 2012). NMFS reviewed the status of this species and efforts being made to protect the species, as well as public comments received on the proposed rule, and made determinations based on the best scientific and commercial data available. In September 2014, NMFS published a Final Rule (79 FR 53851), which concluded that this species did not warrant listing as endangered or threatened under the ESA.

3.8.2.3.14.2 Habitat and Geographic Range

The International Union for Conservation of Nature and Natural Resources and Veron (2000) consider *Isopora cuneata* to be found from the coast of eastern Africa to the central Pacific. According to both the International Union for Conservation of Nature and Natural Resources Species Account and the Convention on International Trade in Endangered Species of Wild Fauna and Flora species database, *Isopora cuneata* occurs in American Samoa and the Northern Mariana Islands. This database also lists it for the U.S. minor outlying islands.

Isopora cuneata is found most commonly in shallow, high-wave energy environments. Although it is occasionally found on sheltered reef slopes and backreef lagoons, it is more typical of reef crests and inner reef flats in water depths ranging from low tide to 15 m (49.2 ft.).

3.8.2.3.14.3 Population and Abundance

Abundance of *Isopora cuneata* has been reported as generally common and occasionally locally abundant (Australian Institute of Marine Science 2010).

3.8.2.3.14.4 Predator-Prey Interactions

Susceptibility of the family Acroporidae to predation stems from reports that most Acropora spp. have been preferentially consumed by crown-of-thorns seastars. In addition, Acropora spp. have been reported to be favored prey of the gastropods Drupella spp. and other corallivorous snails.

3.8.2.3.14.5 Species-Specific Threats

Isopora cuneata is susceptible to the same suite of stressors that generally threaten corals. NMFS evaluated the population's demographic, spatial structure, and vulnerability factors (77 FR 73220–73262) and identified elements that may threaten *Isopora cuneata*. These elements included high vulnerability to ocean warming, moderate vulnerability to disease and acidification, common generalized rangewide abundance, moderate overall distribution (based on moderate geographic distribution and moderate depth distribution), and inadequacy of existing regulatory mechanisms (79 FR 53851).

3.8.2.3.15 *Montipora caliculata* (Pore Coral)

3.8.2.3.15.1 Status and Management

In December 2012, NMFS issued a proposed rule for reef-building coral species, including a proposed listing for the pore coral (*Montipora caliculata*) as threatened (77 FR 73220–73262). NMFS has not proposed a critical habitat designation. The proposed listing was based on a comprehensive status review (Brainard et al. 2011), a summary of management and conservation measures, and a supplemental information report addressing new information and public comment to both status and management reports (National Marine Fisheries Service 2012). NMFS reviewed the status of this species and efforts being made to protect the species, as well as public comments received on the proposed rule, and made determinations based on the best scientific and commercial data available. In September 2014, NMFS published a Final Rule (79 FR 53851), which concluded that this species did not warrant listing as endangered or threatened under the ESA.

3.8.2.3.15.2 Habitat and Geographic Range

Montipora caliculata has a wide distribution from western Sumatra through the Pitcairn Islands. It also has fairly wide latitudinal range from Taiwan to mid-Australia. According to the International Union for Conservation of Nature and Natural Resources Species Account, *Montipora caliculata* occurs in American Samoa, Northern Mariana Islands, and also the U.S. minor outlying islands (DeVantier et al. 2008a).

Montipora caliculata are found in most reef environments at depths of up to 20 m (65.6 ft.).

3.8.2.3.15.3 Population and Abundance

Montipora caliculata are most often reported to be uncommon (Australian Institute of Marine Science 2010).

3.8.2.3.15.4 Predator-Prey Interactions

Montipora spp. are preferred prey of crown-of-thorns seastar.

3.8.2.3.15.5 Species-Specific Threats

Montipora caliculata is susceptible to the same suite of stressors that generally threaten corals. NMFS evaluated the population’s demographic, spatial structure, and vulnerability factors (77 FR 73220–73262) and identified elements that may threaten *Montipora caliculata*. These elements include high vulnerability to ocean warming, moderate vulnerability to disease and acidification, uncommon generalized rangewide abundance, wide overall distribution (based on wide geographic distribution and moderate depth distribution), and inadequacy of existing regulatory mechanisms (79 FR 53851).

3.8.2.3.16 *Montipora lobulata* (Pore Coral)

3.8.2.3.16.1 Status and Management

In December 2012, NMFS issued a proposed rule for reef-building coral species including a proposed listing for the pore coral (*Montipora lobulata*) as threatened (77 FR 73220–73262). NMFS has not proposed a critical habitat designation. The proposed listing was based on a comprehensive status review (Brainard et al. 2011), a summary of management and conservation measures, and a supplemental information report addressing new information and public comment to both status and management reports (National Marine Fisheries Service 2012). NMFS reviewed the status of this species and efforts being made to protect the species, as well as public comments received on the proposed rule, and made determinations based on the best scientific and commercial data available. In September 2014, NMFS published a Final Rule (79 FR 53851), which concluded that this species did not warrant listing as endangered or threatened under the ESA.

3.8.2.3.16.2 Habitat and Geographic Range

Montipora lobulata has a disjoint distribution, with occurrence in the western and central Indian Ocean and the central Pacific. According to the International Union for Conservation of Nature and Natural

Resources Species, *Montipora lobulata* occurs in American Samoa and the Northern Mariana Islands. The species account also lists its occurrence in the U.S. minor outlying islands (DeVantier et al. 2008b).

Montipora lobulata has been reported to inhabit shallow reef environments at depths of up to 20 m (65.6 ft.).

3.8.2.3.16.3 Population and Abundance

Abundance of *Montipora lobulata* has been reported as rare (Australian Institute of Marine Science 2010).

3.8.2.3.16.4 Predator-Prey Interactions

Montipora spp. are preferred prey of crown-of-thorns seastar.

3.8.2.3.16.5 Species-Specific Threats

Montipora lobulata is susceptible to the same suite of stressors that generally threaten corals. NMFS evaluated the population's demographic, spatial structure, and vulnerability factors (77 FR 73220–73262) and identified elements that may threaten *Montipora lobulata*. These elements include high vulnerability to ocean warming, moderate vulnerability to disease and acidification, uncommon generalized rangewide abundance, overall wide distribution (based on wide geographic distribution and moderate depth distribution), and inadequacy of existing regulatory mechanisms (79 FR 53851).

3.8.2.3.17 *Montipora patula* (Pore Coral)

3.8.2.3.17.1 Status and Management

In December 2012, NMFS issued a proposed rule for reef-building coral species including a proposed listing for the pore coral (*Montipora patula*) as threatened (77 FR 73220–73262). NMFS has not proposed a critical habitat designation. The proposed listing was based on a comprehensive status review (Brainard et al. 2011), a summary of management and conservation measures, and a supplemental information report addressing new information and public comment to both status and management reports (National Marine Fisheries Service 2012). This species is proposed for listing as a combined group with *Montipora verrilli* (*Montipora patula/verrilli*). NMFS reviewed the status of this species and efforts being made to protect the species, as well as public comments received on the proposed rule, and made determinations based on the best scientific and commercial data available. In September 2014, NMFS published a Final Rule (79 FR 53851), which concluded that this species did not warrant listing as endangered or threatened under the ESA.

3.8.2.3.17.2 Habitat and Geographic Range

Montipora patula has occurs in the Indo-West Pacific. The International Union for Conservation of Nature and Natural Resources Species Account also lists its occurrence in the U.S. minor outlying islands (DeVantier et al. 2008c).

Montipora patula has been reported to inhabit shallow reef environments at depths of up to at least 10 m (32.8 ft.).

3.8.2.3.17.3 Population and Abundance

Abundance of *Montipora patula* has been reported as rare. *M. verrilli*, the other species in the combined group, is considered uncommon in the CNMI and Guam (International Union for Conservation of Nature 2013b)

3.8.2.3.17.4 Predator-Prey Interactions

Montipora spp. are preferred prey of crown-of-thorns seastar.

3.8.2.3.17.5 Species-Specific Threats

Montipora patula is susceptible to the same suite of stressors that generally threaten corals. NMFS evaluated the population's demographic, spatial structure, and vulnerability factors (77 FR 73220–73262) and identified elements that may threaten *Montipora patula*. These elements included high vulnerability to ocean warming, moderate vulnerability to disease and acidification, uncommon generalized rangewide abundance, overall wide distribution (based on wide geographic distribution and moderate depth distribution), and inadequacy of existing regulatory mechanisms (79 FR 53851).

3.8.2.3.18 *Montipora turgescens* (Pore Coral)

3.8.2.3.18.1 Status and Management

In December 2012, NMFS issued a proposed rule for reef-building coral species, including a proposed listing for the pore coral (*Montipora turgescens*) as threatened (77 FR 73220–73262). It is important to note that *Montipora turgescens* itself was not petitioned for listing; rather, it was included as a combined clade in the proposed listing as *Montipora dilatata/flabellate/turgescens* due to taxonomic similarities. NMFS has not proposed a critical habitat designation. The proposed listing was based on a comprehensive status review (Brainard et al. 2011), a summary of management and conservation measures, and a supplemental information report addressing new information and public comment to both status and management reports (National Marine Fisheries Service 2012). NMFS reviewed the status of this species and efforts being made to protect the species, as well as public comments received on the proposed rule, and made determinations based on the best scientific and commercial data available. In September 2014, NMFS published a Final Rule (79 FR 53851), which concluded that this species did not warrant listing as endangered or threatened under the ESA.

3.8.2.3.18.2 Habitat and Geographic Range

Montipora turgescens occurs in the in the Red Sea and the Gulf of Aden, the southwest and northern Indian Ocean, the central Indo-Pacific, Australia, Southeast Asia, Japan and the East China Sea, the oceanic West Pacific, the Central Pacific, the Hawaiian Islands, and Johnston Atoll (DeVantier et al. 2008d). *Montipora turgescens* has been reported to inhabit shallow reef environments at depths of up to at least 30 m (98.4 ft.).

3.8.2.3.18.3 Population and Abundance

Montipora turgescens has been reported as rare in the Study Area, but has been observed in the waters of Guam (HDR 2011). Note that Brainard et al. (2011) does not list this species as occurring in waters off Guam and the CNMI.

3.8.2.3.18.4 Predator-Prey Interactions

Montipora spp. are preferred prey of crown-of-thorns seastar.

3.8.2.3.18.5 Species-Specific Threats

Montipora turgescens is susceptible to the same suite of stressors that generally threaten corals. NMFS evaluated the population's demographic, spatial structure, and vulnerability factors (77 FR 73220–73262) and identified elements that may threaten *Montipora turgescens*. These elements include high vulnerability to ocean warming, moderate vulnerability to disease and acidification, common generalized rangewide abundance, overall wide distribution (based on wide geographic distribution and moderate depth distribution), and inadequacy of existing regulatory mechanisms (79 FR 53851).

3.8.2.3.19 *Pachyseris rugosa* (Rugosa Coral)

3.8.2.3.19.1 Status and Management

In December 2012, NMFS issued a proposed rule for reef-building coral species including a proposed listing for the rugosa coral (*Pachyseris rugosa*) as threatened (77 FR 73220–73262). NMFS has not proposed a critical habitat designation. The proposed listing was based on a comprehensive status review (Brainard et al. 2011), a summary of management and conservation measures, and a supplemental information report addressing new information and public comment to both status and management reports (National Marine Fisheries Service 2012). NMFS reviewed the status of this species and efforts being made to protect the species, as well as public comments received on the proposed rule, and made determinations based on the best scientific and commercial data available. In September 2014, NMFS published a Final Rule (79 FR 53851), which concluded that this species did not warrant listing as endangered or threatened under the ESA.

3.8.2.3.19.2 Habitat and Geographic Range

Pachyseris rugosa has a very widespread distribution, stretching from the western Indian Ocean into the Pacific. According to the International Union for Conservation of Nature and Natural Resources Species Account, *Pachyseris rugosa* occurs in American Samoa and the Northern Mariana Islands (Hoeksema et al. 2008b).

Pachyseris rugosa may develop into large mound-shaped colonies in shallow water in water depths ranging from 5 to 20 m (16.4 to 65.6 ft.). Smaller colonies occur in a wide range of habitats, including those exposed to strong wave action.

3.8.2.3.19.3 Population and Abundance

Abundance of *Pachyseris rugosa* has been reported as common (Australian Institute of Marine Science 2010).

3.8.2.3.19.4 Predator-Prey Interactions

Mass mortality of this species on the Great Barrier Reef has been attributed to *Acanthaster planci*, although predation was not observed directly.

3.8.2.3.19.5 Species-Specific Threats

Pachyseris rugosa is susceptible to the same suite of stressors that generally threaten corals. NMFS evaluated the population’s demographic, spatial structure, and vulnerability factors (77 FR 73220–73262) and identified elements that may threaten *Pachyseris rugosa*. These elements include high vulnerability to ocean warming, moderate vulnerability to disease and acidification, common generalized rangewide abundance, wide overall distribution (based on wide geographic distribution and moderate depth distribution), and inadequacy of existing regulatory mechanisms (79 FR 53851).

3.8.2.3.20 *Euphyllia cristata* (Grape Coral)

3.8.2.3.20.1 Status and Management

In December 2012, NMFS issued a proposed rule for reef-building coral species, including a proposed listing for the grape coral (*Euphyllia cristata*) as threatened (77 FR 73220–73262). NMFS has not proposed a critical habitat designation. The proposed listing was based on a comprehensive status review (Brainard et al. 2011), a summary of management and conservation measures, and a supplemental information report addressing new information and public comment to both status and management reports (National Marine Fisheries Service 2012). NMFS reviewed the status of this species and efforts being made to protect the species, as well as public comments received on the proposed rule, and made determinations based on the best scientific and commercial data available. In September 2014, NMFS published a Final Rule (79 FR 53851), which concluded that this species did not warrant listing as endangered or threatened under the ESA.

3.8.2.3.20.2 Habitat and Geographic Range

Euphyllia cristata has a moderately wide range, including higher latitude areas in the Ryukus (Japan) and along both coasts of Australia. According to the International Union for Conservation of Nature and Natural Resources Species Account, *Euphyllia cristata* occurs in American Samoa and the Northern Mariana Islands (Turak et al. 2008a).

Euphyllia cristata inhabits shallow reef habitats; the International Union for Conservation of Nature and Natural Resources account includes a wide depth range of 1 to 35 m (3.3 to 114.8 ft.).

3.8.2.3.20.3 Population and Abundance

Abundance of *Euphyllia cristata* has been reported to range from common to uncommon but conspicuous (Australian Institute of Marine Science 2010; Carpenter et al. 2008).

3.8.2.3.20.4 Predator-Prey Interactions

Unknown for *Euphyllia cristata.*

3.8.2.3.20.5 Species-Specific Threats

Euphyllia cristata is susceptible to the same suite of stressors that generally threaten corals. NMFS evaluated the population's demographic, spatial structure, and vulnerability factors (77 FR 73220–73262) and identified elements that may threaten *Euphyllia cristata. These elements include* high vulnerability to ocean warming, moderate vulnerability to disease and acidification; uncommon generalized rangewide abundance, moderate overall distribution (based on moderate geographic distribution and moderate depth distribution), and inadequacy of existing regulatory mechanisms (79 FR 53851).

3.8.2.3.21 *Euphyllia panaacora* (Grape Coral)

3.8.2.3.21.1 Status and Management

In December 2012, NMFS issued a proposed rule for reef-building coral species including a proposed listing for the grape coral (*Euphyllia panaacora*) as threatened (77 FR 73220–73262). NMFS has not proposed a critical habitat designation. The proposed listing was based on a comprehensive status review (Brainard et al. 2011), a summary of management and conservation measures, and a supplemental information report addressing new information and public comment to both status and management reports (National Marine Fisheries Service 2012). NMFS reviewed the status of this species and efforts being made to protect the species, as well as public comments received on the proposed rule, and made determinations based on the best scientific and commercial data available. In September 2014, NMFS published a Final Rule (79 FR 53851), which concluded that this species did not warrant listing as endangered or threatened under the ESA.

3.8.2.3.21.2 Habitat and Geographic Range

Euphyllia paraancora has a restricted range, both longitudinally and latitudinally. According to the International Union for Conservation of Nature and Natural Resources Species Account, *Euphyllia* *paraancora* occurs in the Northern Mariana Islands (Turak et al. 2008b). The Convention on International Trade in Endangered Species of Wild Fauna and Flora database does not list its occurrence in U.S. waters.

Euphyllia paraancora has been reported from shallow and deep reef environments protected from wave action in water depths ranging from 3 to 30 m (9.8 to 98.4 ft.).

3.8.2.3.21.3 Population and Abundance

Abundance of *Euphyllia paraancora* has been reported to be uncommon (Turak et al. 2008b).

3.8.2.3.21.4 Predator-Prey Interactions

Unknown for *Euphyllia paraancora.*

3.8.2.3.21.5 Species-Specific Threats

Euphyllia paraacora is susceptible to the same suite of stressors that generally threaten corals. NMFS evaluated the population's demographic, spatial structure, and vulnerability factors (77 FR 73220–73262) and identified elements that may threaten *Euphyllia paraancora*. These elements include high vulnerability to ocean warming, moderate vulnerability to disease and acidification, uncommon generalized rangewide abundance, wide overall distribution (based on moderate geographic distribution and wide depth distribution), and inadequacy of existing regulatory mechanisms (79 FR 53851).

3.8.2.3.22 *Physogyra lichtensteini* (Grape Coral)

3.8.2.3.22.1 Status and Management

In December 2012, NMFS issued a proposed rule for reef-building coral species including a proposed listing for the grape coral (*Physogyra lichtensteini*) as threatened (77 FR 73220–73262). NMFS has not proposed a critical habitat designation. The proposed listing was based on a comprehensive status review (Brainard et al. 2011), a summary of management and conservation measures, and a supplemental information report addressing new information and public comment to both status and management reports (National Marine Fisheries Service 2012). NMFS reviewed the status of this species and efforts being made to protect the species, as well as public comments received on the proposed rule, and made determinations based on the best scientific and commercial data available. In September 2014, NMFS published a Final Rule (79 FR 53851), which concluded that this species did not warrant listing as endangered or threatened under the ESA.

3.8.2.3.22.2 Habitat and Geographic Range

Physogyra lichtensteini has a relatively broad distribution. It is found in Australia, Indonesia, Japan, Kenya, Madagascar, the Seychelles, the Red Sea, the Arabian Sea, India, the Philippines, and other areas in the west Pacific. According to the International Union for Conservation of Nature and Natural Resources Species Account, *Physogyra lichtensteini* occurs in the Northern Mariana Islands (Turak et al. 2008c).

Physogyra lichtensteini has been reported to occupy turbid reef environments (Australian Institute of Marine Science 2010). The species is common in protected habitats (crevices and overhangs), especially in turbid water with tidal currents in water depths ranging from 1 to 20 m (3.3 to 65.6 ft.).

3.8.2.3.22.3 Population and Abundance

Abundance of *Physogyra lichtensteini* has been reported to be common in protected habitats such as crevices and overhangs, especially in turbid water with tidal currents (Australian Institute of Marine Science 2010).

3.8.2.3.22.4 Predator-Prey Interactions

Population-level effects of predation are unknown for *Physogyra lichtensteini*, although it is preyed upon on by butterflyfish in Indonesia.

3.8.2.3.22.5 Species-Specific Threats

Physogyra lichtensteini is susceptible to the same suite of stressors that generally threaten corals. NMFS evaluated the population's demographic, spatial structure, and vulnerability factors (77 FR 73220–73262) and identified elements that may threaten *Physogyra lichtensteini*. These elements include high vulnerability to ocean warming, moderate vulnerability to disease and acidification, common generalized rangewide abundance, wide overall distribution (based on wide geographic distribution and moderate depth distribution), and inadequacy of existing regulatory mechanisms (79 FR 53851).

3.8.2.3.23 *Barabattoia laddi* (Faviid Coral)

3.8.2.3.23.1 Status and Management

In December 2012, NMFS issued a proposed rule for reef-building coral species including a proposed listing for the faviid coral (*Barabattoia laddi*) as threatened (77 FR 73220–73262). NMFS has not proposed a critical habitat designation. The proposed listing is based on a comprehensive status review (Brainard et al. 2011), a summary of management and conservation measures, and a supplemental information report addressing new information and public comment to both status and management reports (National Marine Fisheries Service 2012). NMFS reviewed the status of this species and efforts being made to protect the species, as well as public comments received on the proposed rule, and made determinations based on the best scientific and commercial data available. In September 2014, NMFS published a Final Rule (79 FR 53851), which concluded that this species did not warrant listing as endangered or threatened under the ESA.

3.8.2.3.23.2 Habitat and Geographic Range

The range of *Barabattoia laddi* is somewhat restricted, latitudinally. It is highly centered in the Coral Triangle but also found around some of the islands in the western Pacific, central South Pacific, and Australia's Great Barrier Reef. According to the International Union for Conservation of Nature and Natural Resources Species Account, *Barabattoia laddi* occurs in the Northern Mariana Islands (DeVantier et al. 2008e).

Barabattoia laddi has been recorded only from shallow lagoons in water depths ranging from 0 to 10 m (0 to 32.8 ft.).

3.8.2.3.23.3 Population and Abundance

Abundance of *Barabattoia laddi* has been reported to be rare (Australian Institute of Marine Science 2010).

3.8.2.3.23.4 Predator-Prey Interactions

Susceptibility to predation is unknown for *Barabattoia laddi*.

3.8.2.3.23.5 Species-Specific Threats

Barabattoia laddi is susceptible to the same suite of stressors that generally threaten corals. NMFS evaluated the population's demographic, spatial structure, and vulnerability factors (77 FR 73220–73262) and identified elements that may threaten *Barabattoia laddi*. These elements include moderate vulnerability to ocean warming, disease, and acidification; uncommon generalized rangewide abundance; narrow overall distribution (based on moderate geographic distribution and shallow depth distribution); and inadequacy of existing regulatory mechanisms (79 FR 53851).

3.8.2.3.24 *Millepora foveolata* (Fire Coral)

3.8.2.3.24.1 Status and Management

In December 2012, NMFS issued a proposed rule for reef-building coral species, including a proposed listing for the fire coral (*Millepora foveolata*) as endangered (77 FR 73220–73262). NMFS has not proposed a critical habitat designation. The proposed listing was based on a comprehensive status review (Brainard et al. 2011), a summary of management and conservation measures, and a supplemental information report addressing new information and public comment to both status and management reports (National Marine Fisheries Service 2012). NMFS reviewed the status of this species and efforts being made to protect the species, as well as public comments received on the proposed rule, and made determinations based on the best scientific and commercial data available. In September 2014, NMFS published a Final Rule (79 FR 53851), which concluded that this species did not warrant listing as endangered or threatened under the ESA.

3.8.2.3.24.2 Habitat and Geographic Range

Millepora foveolata has been reported on the southern coast of Taiwan, the Philippines, the Northern Marianas (but not the Southern Marianas, which include Guam, Rota, Tinian, Saipan); and the Great Barrier Reef in Australia (Brainard et al. 2011). According to the International Union for Conservation of Nature and Natural Resources Species Account, *Millepora foveolata* occurs in American Samoa (Obura et al. 2008).

Specimens of *Millepora foveolata* have been collected from the forefront reef slope on the upper surface of buttress ridges and have been reported in water depths ranging from at least 1 to 8 m (3.3 to 26.2 ft.).

3.8.2.3.24.3 Population and Abundance

Abundance of *Millepora foveolata* has been reported mostly as occasional (Brainard et al. 2011).

3.8.2.3.24.4 Predator-Prey Interactions

Species of the Milleporidae family are known to be preyed on by the crown-of-thorns seastar, although they are less preferred prey than members of the Acroporidae family. Milleporids are also susceptible to predation by the polychaete *Hermodice carunculata*, the nudibranch mollusk *Phyllidia*, and filefish of the genera *Alutera* and *Cantherhines.*

3.8.2.3.24.5 Species-Specific Threats

Millepora foveolata is susceptible to the same suite of stressors that generally threaten corals. NMFS evaluated the population's demographic, spatial structure, and vulnerability factors (77 FR 73220–73262) and identified elements that may threaten *Millepora foveolata*. These elements include high vulnerability to ocean warming, moderate vulnerability to disease and acidification, uncommon generalized rangewide abundance, narrow overall distribution (based on narrow geographic distribution and shallow depth distribution), and inadequacy of existing regulatory mechanisms (79 FR 53851).

3.8.2.3.25 *Millepora tuberosa* (Fire Coral)

3.8.2.3.25.1 Status and Management

In December 2012, NMFS issued a proposed rule for reef-building coral species, including a proposed listing for the fire coral (*Millepora tuberosa*) as threatened (77 FR 73220–73262). NMFS has not proposed a critical habitat designation. The proposed listing was based on a comprehensive status review (Brainard et al. 2011), a summary of management and conservation measures, and a supplemental information report addressing new information and public comment to both status and management reports (National Marine Fisheries Service 2012). NMFS reviewed the status of this species and efforts being made to protect the species, as well as public comments received on the proposed rule, and made determinations based on the best scientific and commercial data available. In September 2014, NMFS published a Final Rule (79 FR 53851), which concluded that this species did not warrant listing as endangered or threatened under the ESA.

3.8.2.3.25.2 Habitat and Geographic Range

Millepora tuberosa is occasionally common in portions of the western Pacific (Taiwan, Mariana lslands, Caroline Islands) and is found in American Samoa.

Millepora tuberosa has been reported to occupy a variety of habitats, including the forest reef and lagoonal areas in water depths ranging from at least 1 to 12 m (3.3 to 39.4 ft.).

3.8.2.3.25.3 Population and Abundance

Abundance of *Millepora tuberosa* has most often been reported as occasional, but it has been observed as predominant in an area of lagoonal reef in southwest Guam near the Agat Boat Harbor (Brainard et al. 2011).

3.8.2.3.25.4 Predator-Prey Interactions

Species of the Milleporidae family are known to be preyed on by the crown-of-thorns seastar, although they are less preferred prey than members of the Acroporidae family. Milleporids are also susceptible to predation by the polychaete *Hermodice carunculata*, the nudibranch mollusk *Phyllidia*, and filefish of the genera *Alutera* and *Cantherhines.*

3.8.2.3.25.5 Species-Specific Threats

Millepora tuberosa is susceptible to the same suite of stressors that generally threaten corals. NMFS evaluated the population’s demographic, spatial structure, and vulnerability factors (77 FR 73220–73262) and identified elements that may threaten *Millepora tuberosa.* These elements include high vulnerability to ocean warming, moderate vulnerability to disease and acidification, common generalized rangewide abundance, narrow overall distribution (based on narrow geographic distribution and shallow depth distribution), and inadequacy of existing regulatory mechanisms (79 FR 53851).

3.8.2.3.26 *Acanthastrea brevis* (Starry Cup Coral)

3.8.2.3.26.1 Status and Management

In December 2012, NMFS issued a proposed rule for reef-building coral species, including a proposed listing for the starry cup coral (*Acanthastrea brevis*) as threatened (77 FR 73220–73262). NMFS has not proposed a critical habitat designation. The proposed listing was based on a comprehensive status review (Brainard et al. 2011), a summary of management and conservation measures, and a supplemental information report addressing new information and public comment to both status and management reports (National Marine Fisheries Service 2012). NMFS reviewed the status of this species and efforts being made to protect the species, as well as public comments received on the proposed rule, and made determinations based on the best scientific and commercial data available. In September 2014, NMFS published a Final Rule (79 FR 53851), which concluded that this species did not warrant listing as endangered or threatened under the ESA.

3.8.2.3.26.2 Habitat and Geographic Range

Acanthastrea brevis has wide distribution ranging from the Red Sea, Gulf of Aden, southwest Indian Ocean, and northern Indian Ocean to central Indo-Pacific, west Pacific, Great Barrier Reef, and Fiji. According to the International Union for Conservation of Nature and Natural Resources Species Account, *Acanthastrea brevis* occurs in American Samoa and in the northern Mariana Islands (Turak et al. 2008d). No supporting reference is given in the species account for the stated record of occurrence in the Northern Mariana Islands.

Acanthastrea brevis has been reported to occupy shallow reef environments (Australian Institute of Marine Science 2010) and all types of reef habitats. *Acanthastrea brevis* has been reported at water depths ranging from 1 to 20 m (3.3 to 65.6 ft.).

3.8.2.3.26.3 Population and Abundance

Abundance of *Acanthastrea brevis* has been reported as uncommon but conspicuous (Australian Institute of Marine Science 2010).

3.8.2.3.26.4 Predator-Prey Interactions

The specific predation threats upon members of the Family Mussidae (*Acanthastrea* sp.) found in the MITT Study Area are unknown (Brainard et al. 2011).

3.8.2.3.26.5 Species-Specific Threats

Acanthastrea brevis is susceptible to the same suite of stressors that generally threaten corals. NMFS evaluated the population’s demographic, spatial structure, and vulnerability factors (77 FR 73220–73262) and identified elements that may threaten *Acanthastrea brevis*. These elements include high vulnerability to ocean warming, moderate vulnerability to disease and acidification, uncommon generalized rangewide abundance, wide overall distribution (based on wide geographic range and moderate depth distribution), and inadequacy of existing regulatory mechanisms (79 FR 53851).

3.8.2.3.27 *Acanthastrea ishigakiensis* (Starry Cup Coral)

3.8.2.3.27.1 Status and Management

In December 2012, NMFS issued a proposed rule for reef-building coral species, including a proposed listing for the starry cup coral (*Acanthastrea ishigakiensis*) as threatened (77 FR 73220–73262). NMFS has not proposed a critical habitat designation. The proposed listing was based on a comprehensive status review (Brainard et al. 2011), a summary of management and conservation measures, and a supplemental information report addressing new information and public comment to both status and management reports (National Marine Fisheries Service 2012). NMFS reviewed the status of this species and efforts being made to protect the species, as well as public comments received on the proposed rule, and made determinations based on the best scientific and commercial data available. In September 2014, NMFS published a Final Rule (79 FR 53851), which concluded that this species did not warrant listing as endangered or threatened under the ESA.

3.8.2.3.27.2 Habitat and Geographic Range

Acanthastrea ishigakiensis has a broad range; it stretches from the Red Sea, Gulf of Aden, and southern Africa to the central Pacific Ocean as far as Samoa but not including Australia. According to the

International Union for Conservation of Nature and Natural Resources Species Account, *Acanthastrea ishigakiensis* occurs in American Samoa and the Northern Mariana Islands, but no supporting reference is given for the record of occurrence in either of these areas in the species account.

Acanthastrea ishigakiensis has been reported to occupy shallow protected reef environments in water depths ranging from 1 to 15 m (3.3 to 49.2 ft.).

3.8.2.3.27.3 Population and Abundance

Abundance of *Acanthastrea ishigakiensis* has been reported as uncommon but conspicuous (Australian Institute of Marine Science 2010).

3.8.2.3.27.4 Predator-Prey Interactions

The specific predation threats upon members of the Family Mussidae (*Acanthastrea* sp.) found in the MITT Study Area are unknown (Brainard et al. 2011).

3.8.2.3.27.5 Species-Specific Threats

Acanthastrea ishigakiensis is susceptible to the same suite of stressors that generally threaten corals. NMFS evaluated the population's demographic, spatial structure, and vulnerability factors (77 FR 73220–73262) and identified elements that may threaten *Acanthastrea ishigakiensis*. These elements include high vulnerability to ocean warming, moderate vulnerability to disease and acidification, uncommon generalized rangewide abundance, moderate overall distribution (based on wide geographic distribution and shallow depth distribution), and inadequacy of existing regulatory mechanisms (79 FR 53851).

3.8.2.3.28 *Acanthastrea regularis* (Starry Cup Coral)

3.8.2.3.28.1 Status and Management

In December 2012, NMFS issued a proposed rule for reef-building coral species, including a proposed listing for the starry cup coral (*Acanthastrea regularis*) as threatened (77 FR 73220–73262). NMFS has not proposed a critical habitat designation. The proposed listing was based on a comprehensive status review (Brainard et al. 2011), a summary of management and conservation measures, and a supplemental information report addressing new information and public comment to both status and management reports (National Marine Fisheries Service 2012). NMFS reviewed the status of this species and efforts being made to protect the species, as well as public comments received on the proposed rule, and made determinations based on the best scientific and commercial data available. In September 2014, NMFS published a Final Rule (79 FR 53851), which concluded that this species did not warrant listing as endangered or threatened under the ESA.

3.8.2.3.28.2 Habitat and Geographic Range

Distribution is fairly restricted both longitudinally as latitudinally. It is highly centered in the Coral Triangle but also found around some of the islands in the west Pacific and Australia's Great Barrier Reef. According to the International Union for Conservation of Nature and Natural Resources Species Account, *Acanthastrea regularis* occurs in the Northern Mariana Islands, but no supporting reference is given.

Acanthastrea regularis has been reported to occupy shallow reef environments in water depths ranging from 2 to 20 m (6.6 to 65.6 ft.).

3.8.2.3.28.3 Population and Abundance

Abundance of *Acanthastrea regularis* has been reported as uncommon (Australian Institute of Marine Science 2010).

3.8.2.3.28.4 Predator-Prey Interactions

The specific predation threats upon members of the Family Mussidae (Acanthastrea sp.) found in the MITT Study Area are unknown (Brainard et al. 2011).

3.8.2.3.28.5 Species-Specific Threats

Acanthastrea regularis is susceptible to the same suite of stressors that generally threaten corals. NMFS evaluated the population's demographic, spatial structure, and vulnerability factors (77 FR 73220–73262) and identified elements that may threaten *Acanthastrea regularis*. These elements include high vulnerability to ocean warming, moderate vulnerability to disease and acidification, uncommon generalized rangewide abundance, moderate overall distribution (based on moderate geographic distribution and moderate depth distribution), and inadequacy of existing regulatory mechanisms (79 FR 53851).

3.8.2.3.29 *Pectinia alcicornis* (Lettuce Coral)

3.8.2.3.29.1 Status and Management

In December 2012, NMFS issued a proposed rule for reef-building coral species, including a proposed listing for the lettuce coral (*Pectinia alcicornis*) as threatened (77 FR 73220–73262). NMFS has not proposed a critical habitat designation. The proposed listing was based on a comprehensive status review (Brainard et al. 2011), a summary of management and conservation measures, and a supplemental information report addressing new information and public comment to both status and management reports (National Marine Fisheries Service 2012). NMFS reviewed the status of this species and efforts being made to protect the species, as well as public comments received on the proposed rule, and made determinations based on the best scientific and commercial data available. In September 2014, NMFS published a Final Rule (79 FR 53851), which concluded that this species did not warrant listing as endangered or threatened under the ESA.

3.8.2.3.29.2 Habitat and Geographic Range

Pectinia alcicornis is broadly distributed in the Indo-Pacific, including Australia, Fiji, Indonesia, Japan, the Philippines, and India. U.S.-affiliated waters within the Indo-West Pacific range include American Samoa, the Marshall Islands, Micronesia, the Northern Mariana Islands, Palau, and unspecified U.S. minor outlying islands.

Pectinid corals can be found in turbid, horizontal reef environments to approximately 25 m (82.0 ft.) deep.

3.8.2.3.29.3 Population and Abundance

Abundance of *Pectinia alcicornis* has been reported as usually uncommon (Australian Institute of Marine Science 2010).

3.8.2.3.29.4 Predator-Prey Interactions

Members of the Pectinidae family are highly susceptible to crown-of-thorns seastar. However, little is known about the potential population-level impacts for *Pectinia alcicornis*.

3.8.2.3.29.5 Species-Specific Threats

Pectina alcicornis is susceptible to the same suite of stressors that generally threaten corals. NMFS evaluated the population's demographic, spatial structure, and vulnerability factors (77 FR 73220–73262) and identified elements that may threaten *Pectinia alcicornis*. These elements include high vulnerability to ocean warming, moderate vulnerability to disease and acidification, uncommon generalized rangewide abundance, wide overall distribution (based on wide geographic range and moderate depth distribution), and inadequacy of existing regulatory mechanisms (79 FR 53851).

3.8.2.3.30 *Pocillopora danae* (Cauliflower Coral)

3.8.2.3.30.1 Status and Management

In December 2012, NMFS issued a proposed rule for reef-building coral species, including a proposed listing for the cauliflower coral (*Pocillopora danae*) as threatened (77 FR 73220–73262). NMFS has not proposed a critical habitat designation. The proposed listing was based on a comprehensive status review (Brainard et al. 2011), a summary of management and conservation measures, and a supplemental information report addressing new information and public comment to both status and management reports (National Marine Fisheries Service 2012). NMFS reviewed the status of this species and efforts being made to protect the species, as well as public comments received on the proposed rule, and made determinations based on the best scientific and commercial data available. In September 2014, NMFS published a Final Rule (79 FR 53851), which concluded that this species did not warrant listing as endangered or threatened under the ESA.

3.8.2.3.30.2 Habitat and Geographic Range

Pocillopora danae has a somewhat broad longitudinal and latitudinal range. It has been reported throughout the western Pacific and a small part of the central Pacific, the Great Barrier Reef, and around Sri Lanka. According to the International Union for Conservation of Nature and Natural Resources Species Account, *Pocillopora danae* has been recorded in the Northern Mariana Islands (Hoeksema et al. 2008c).

Pocillopora danae has been reported on partly protected reef slopes in water depths ranging from 1 to 15 m (49.2 ft.).

3.8.2.3.30.3 Population and Abundance

Abundance of *Pocillopora Danae* has usually been reported to be uncommon (Carpenter et al. 2008; Australian Institute of Marine Science 2010).

3.8.2.3.30.4 Predator-Prey Interactions

Species of the Pocilloporidae family are among the most commonly consumed coral genera by crown-of-thorns seastar (*Acanthaster planci*) (Glynn 1976). However, Pocillopora are defended from Acanthaster predation by two mutualistic crustacean symbionts: a crab and a snapping shrimp, which often form protective barriers around unprotected species (Glynn 1976). Because smaller colonies lack these symbionts, Acanthaster often target young colonies, potentially reducing recruit success. Additionally, Pocillopora has been identified as preferred prey for corallivorous invertebrates such as the asteroid *Culcita novaeguineae* (Brainard et al. 2011), the gastropod *Jenneria pustulata* (Glynn 1976), and corallivorous fishes.

3.8.2.3.30.5 Species-Specific Threats

Pocillopora danae is susceptible to the same suite of stressors that generally threaten corals. NMFS evaluated the population's demographic, spatial structure, and vulnerability factors (77 FR 73220–73262) and identified elements that may threaten *Pocillopora danae*. These elements include high vulnerability to ocean warming, moderate vulnerability to disease and acidification, uncommon generalized rangewide abundance, moderate overall distribution (based on moderate geographic distribution and moderate depth distribution), and inadequacy of existing regulatory mechanisms (79 FR 53851).

3.8.2.3.31 *Pocillopora elegans,* Indo-Pacific (Cauliflower Coral)

3.8.2.3.31.1 Status and Management

In December 2012, NMFS issued a proposed rule for reef-building coral species, including a proposed listing for the cauliflower coral (*Pocillopora elegans*) as threatened (77 FR 73220–73262). *Pocillipora elegans* is treated as two regional populations in the proposed listing: *P. elegans* (Indo-Pacific) and *P. elegans* (Eastern Pacific). Only the Indo-Pacific regional population is proposed as "threatened." NMFS has not proposed a critical habitat designation. The proposed listing was based on a comprehensive status review (Brainard et al. 2011), a summary of management and conservation measures, and a supplemental information report addressing new information and public comment to both status and management reports (National Marine Fisheries Service 2012). NMFS reviewed the status of this species and efforts being made to protect the species, as well as public comments received on the proposed rule, and made determinations based on the best scientific and commercial data available. In September 2014, NMFS published a Final Rule (79 FR 53851), which concluded that this species did not warrant listing as endangered or threatened under the ESA.

3.8.2.3.31.2 Habitat and Geographic Range

The global distribution of both the Indo-Pacific and Eastern Pacific populations of *Pocillopora elegans* is rather fragmented; it is found in the central Indo-Pacific, the Marianas and central Pacific, and along the coastline of the eastern tropical Pacific and the Galapagos Islands. According to the International Union for Conservation of Nature and Natural Resources Species Account, *Pocillopora elegans* has been recorded in American Samoa and the Northern Mariana Islands (Hoeksema et al. 2008d). The species account also lists its occurrence in the U.S. minor outlying islands.

Pocillipora elegans has been reported from shallow reef in water depths ranging from 1 to 20 m (3.3 to 65.6 ft.). However, it has been found at a depth of 60 m (196.9 ft.), suggesting the potential for deep refugia.

3.8.2.3.31.3 Population and Abundance

Abundance of *Pocillipora elegans* has been reported to be locally common in some regions of the central Indo-Pacific and the far eastern Pacific (Carpenter et al. 2008; Australian Institute of Marine Science 2010).

3.8.2.3.31.4 Predator-Prey Interactions

Species of the Pocilloporidae family are among the most commonly consumed coral genera by crown-of-thorns seastar (*Acanthaster planci*). Additionally, Pocillopora has been identified as preferred prey for corallivorous invertebrates such as the asteroid *Culcita novaeguineae* (Brainard et al. 2011), the gastropod *Jenneria pustulata* (Glynn 1976), and corallivorous fishes.

3.8.2.3.31.5 Species-Specific Threats

Pocillopora elegans is susceptible to the same suite of stressors that generally threaten corals. NMFS evaluated the population's demographic, spatial structure, and vulnerability factors (77 FR 73220–73262) and identified elements that may threaten *Pocillopora elegans*' (Indo-Pacific). These elements include high vulnerability to ocean warming, moderate vulnerability to disease and acidification, common generalized range-wide abundance, wide overall distribution (based on wide geographic distribution and wide depth distribution), and inadequacy of existing regulatory mechanisms (79 FR 53851).

3.8.2.3.32 *Alveopora allingi* (Net Coral)

3.8.2.3.32.1 Status and Management

In December 2012, NMFS issued a proposed rule for reef-building coral species, including a proposed listing for the net coral (*Alveopora allingi*) as threatened (77 FR 73220–73262). NMFS has not proposed a critical habitat designation. The proposed listing was based on a comprehensive status review (Brainard et al. 2011), a summary of management and conservation measures, and a supplemental information report addressing new information and public comment to both status and management reports (National Marine Fisheries Service 2012). NMFS reviewed the status of this species and efforts being made to protect the species, as well as public comments received on the proposed rule, and made determinations based on the best scientific and commercial data available. In September 2014, NMFS published a Final Rule (79 FR 53851), which concluded that this species did not warrant listing as endangered or threatened under the ESA.

3.8.2.3.32.2 Habitat and Geographic Range

Alveopora allingi has a very broad range, extending from the Red Sea and East Africa to the central Pacific. It extends latitudinally from the Japanese Ryukyu Islands and Red Sea in the northern hemisphere across the Great Barrier Reef and down both coastlines of Australia and South Africa in the southern hemisphere. According to both the International Union for Conservation of Nature and Natural Resources Species Account, *Alveopora allingi* occurs in American Samoa, the Northern Mariana Islands and U.S. minor outlying islands (Sheppard et al. 2008a).

Alveopora allingi has been reported to occupy protected reef environments in water depths ranging from 5 to 10 m (16.4 to 32.8 ft.).

3.8.2.3.32.3 Population and Abundance

Abundance of *Alveopora allingi* has been reported as usually uncommon (Australian Institute of Marine Science 2010).

3.8.2.3.32.4 Predator-Prey Interactions

The specific predation threats upon Alveopora allingi are unknown (Brainard et al. 2011). However, species of the Portidae family (e.g., *Porites, Alveopora* spp.) are susceptible to crown-of-thorns seastar and corallivorous snail predation. Porites are susceptible, but are not a preferred prey, of the predatory asteroid *Culcita novaeguineae* and the butterflyfish *Chaetodon unimaculatus*.

3.8.2.3.32.5 Species-Specific Threats

Alveopora allingi is susceptible to the same suite of stressors that generally threaten corals. NMFS evaluated the population's demographic, spatial structure, and vulnerability factors (77 FR 73220–73262) and identified elements that may threaten *Alveopora allingi*. These elements include high vulnerability to ocean warming, moderate vulnerability to disease and acidification, uncommon relative rangewide abundance, moderate overall distribution (based on wide geographic distribution and shallow depth distribution), and inadequacy of existing regulatory mechanisms (79 FR 53851).

3.8.2.3.33 *Alveopora fenestrata* (Net Coral)

3.8.2.3.33.1 Status and Management

In December 2012, NMFS issued a proposed rule for reef-building coral species, including a proposed listing for the net coral (*Alveopora fenestrata*) as threatened (77 FR 73220–73262). NMFS has not proposed a critical habitat designation. The proposed listing was based on a comprehensive status review (Brainard et al. 2011), a summary of management and conservation measures, and a supplemental information report addressing new information and public comment to both status and management reports (National Marine Fisheries Service 2012). NMFS reviewed the status of this species and efforts being made to protect the species, as well as public comments received on the proposed rule, and made determinations based on the best scientific and commercial data available. In September 2014, NMFS published a Final Rule (79 FR 53851), which concluded that this species did not warrant listing as endangered or threatened under the ESA.

3.8.2.3.33.2 Habitat and Geographic Range

Alveopora fenestrata has a relatively broad range. Longitudally it stretches from the Red Sea to the oceanic west Pacific and latitudinally from the Red Sea and the Northern Mariana Islands on the northern hemisphere to southern Africa and across both coasts of Australia in the Southern hemisphere. According to the International Union for Conservation of Nature and Natural Resources Species Account, *Alveopora fenestrata* occurs in the Northern Mariana Islands (Sheppard et al. 2008b).

Alveopora fenestrata has been reported to occupy shallow reef environments in water depths ranging from 3 to 30 m (9.8 to 98.4 ft.).

3.8.2.3.33.3 Population and Abundance

Abundance of *Alveopora fenestrata* has been reported as uncommon (Australian Institute of Marine Science 2010).

3.8.2.3.33.4 Predator-Prey Interactions

The specific predation threats upon *Alveopora fenestrata* are unknown (Brainard et al. 2011). However, species of the Portidae family (e.g., *Porites, Alveopora* spp.) are susceptible to crown-of-thorns seastar and corallivorous snail predation. Porites are susceptible, but are not a preferred prey, of the predatory asteroid *Culcita novaeguineae* and the butterflyfish *Chaetodon unimaculatus*.

3.8.2.3.33.5 Species-Specific Threats

Alveopora fenestrata is susceptible to the same suite of stressors that generally threaten corals. NMFS evaluated the population's demographic, spatial structure, and vulnerability factors (77 FR 73220–73262) and identified elements that may threaten *Alveopora fenestrata*. These elements include high vulnerability to ocean warming, moderate vulnerability to disease and acidification, uncommon relative range-wide abundance, wide overall distribution (based on wide geographic distribution and moderate depth distribution), and inadequacy of existing regulatory mechanisms (79 FR 53851).

3.8.2.3.34 *Alveopora verrilliana* (Net Coral)

3.8.2.3.34.1 Status and Management

In December 2012, NMFS issued a proposed rule for reef-building coral species, including a proposed listing for the net coral (*Alveopora verrilliana*) as threatened (77 FR 73220–73262). NMFS has not proposed a critical habitat designation. The proposed listing was based on a comprehensive status review (Brainard et al. 2011), a summary of management and conservation measures, and a supplemental information report addressing new information and public comment to both status and management reports (National Marine Fisheries Service 2012). NMFS reviewed the status of this species and efforts being made to protect the species, as well as public comments received on the proposed rule, and made determinations based on the best scientific and commercial data available. In September 2014, NMFS published a Final Rule (79 FR 53851), which concluded that this species did not warrant listing as endangered or threatened under the ESA.

3.8.2.3.34.2 Habitat and Geographic Range

Alveopora verrilliana has a broad range. It stretches from the Red Sea to the central Pacific Ocean longitudinally and latitudinally from the Japanese Ryukyu Islands in the northern hemisphere and midway along both Australian coasts in the southern hemisphere. According to the International Union for Conservation of Nature and Natural Resources Species Account, *Alveopora verrilliana* occurs in American Samoa, the Northern Mariana Islands, and minor outlying islands (Sheppard et al. 2008c).

Alveopora verrilliana has been reported to occupy shallow reef environments in water depths ranging from 3 to 40 m (9.8 to 131.2 ft.). It has also been reported on outer steep slopes from 20 to 80 m (65.6 to 262.5 ft.) deep in the Red Sea, suggesting the potential for deep refugia.

3.8.2.3.34.3 Population and Abundance

Abundance of *Alveopora verrilliana* has been reported to be uncommon (Australian Institute of Marine Science 2010).

3.8.2.3.34.4 Predator-Prey Interactions

The specific predation threats upon *Alveopora verrilliana* are unknown (Brainard et al. 2011). However, species of the Portidae family (e.g., Porites, *Alveopora* spp.) are susceptible to crown-of-thorns seastar and corallivorous snail predation. Porites are susceptible, but are not a preferred prey, of the predatory asteroid *Culcita novaeguineae* and the butterflyfish *Chaetodon unimaculatus*.

3.8.2.3.34.5 Species-Specific Threats

Alveopora verrilliana is susceptible to the same suite of stressors that generally threaten corals. NMFS evaluated the population’s demographic, spatial structure, and vulnerability factors (77 FR 73220–73262) and identified elements that may threaten *Alveopora verrilliana*. These elements include high vulnerability to ocean warming, moderate vulnerability to disease and acidification, uncommon relative rangewide abundance, wide overall distribution (based on wide geographic distribution and wide depth distribution), and inadequacy of existing regulatory mechanisms (79 FR 53851).

3.8.2.3.35 *Porites horizontalata* (Hump Coral)

3.8.2.3.35.1 Status and Management

In December 2012, NMFS issued a proposed rule for reef-building coral species, including a proposed listing for the hump coral (*Porites horizontalata*) as threatened (77 FR 73220–73262). NMFS has not proposed a critical habitat designation. The proposed listing was based on a comprehensive status review (Brainard et al. 2011), a summary of management and conservation measures, and a supplemental information report addressing new information and public comment to both status and management reports (National Marine Fisheries Service 2012). NMFS reviewed the status of this species and efforts being made to protect the species, as well as public comments received on the proposed rule, and made determinations based on the best scientific and commercial data available. In September

2014, NMFS published a Final Rule (79 FR 53851), which concluded that this species did not warrant listing as endangered or threatened under the ESA.

3.8.2.3.35.2 Habitat and Geographic Range

The range of *Porites horizontalata* is somewhat restricted longitudinally from the Maldives in the west to the central Pacific in the east and latitudinally from south of Japan in the northern hemisphere to New Caledonia in the southern hemisphere. According to the International Union for Conservation of Nature and Natural Resources Species Account, *Porites horizontalata* has been recorded in American Samoa and the Northern Mariana Islands (Sheppard et al. 2008d). The species account also lists this species in the U.S. minor outlying islands.

Porites horizontalata has been reported to occupy shallow reef environments in water depths ranging from 5 to 20 m (16.4 to 65.6 ft.). It is also known to range in depth from moderate to deep water in American Samoa and in New Caledonia.

3.8.2.3.35.3 Population and Abundance

Abundance of *Porites horizontalata* has been reported as sometimes common (Carpenter et al. 2008; Australian Institute of Marine Science 2010).

3.8.2.3.35.4 Predator-Prey Interactions

Porites is susceptible to crown-of-thorns seastar (*Acanthaster planci*) and corallivorous snail predation including predation of *Coralliphilia violacea* on both massive and branching forms. Massive Porites are susceptible, but not a preferred prey, of the predatory asteroid *Culcita novaeguineae* and the butterflyfish *Chaetodon unimaculatus*.

3.8.2.3.35.5 Species-Specific Threats

Porites horizontalata is susceptible to the same suite of stressors that generally threaten corals. NMFS evaluated the population's demographic, spatial structure, and vulnerability factors (77 FR 73220–73262) and identified elements that may threaten *Porites horizontilata*. These elements include high vulnerability to ocean warming, moderate vulnerability to disease and acidification, common generalized rangewide abundance, wide overall distribution (based on wide geographic distribution and moderate depth distribution), and inadequacy of existing regulatory mechanisms (79 FR 53851).

3.8.2.3.36 *Porites nigrescens* (Hump Coral)

3.8.2.3.36.1 Status and Management

In December 2012, NMFS issued a proposed rule for reef-building coral species, including a proposed listing for the hump coral (*Porites nigrescens*) as threatened (77 FR 73220–73262). NMFS has not proposed a critical habitat designation. The proposed listing was based on a comprehensive status review (Brainard et al. 2011), a summary of management and conservation measures, and a supplemental information report addressing new information and public comment to both status and management reports (National Marine Fisheries Service 2012). NMFS reviewed the status of this species and efforts being made to protect the species, as well as public comments received on the proposed rule, and made determinations based on the best scientific and commercial data available. In September 2014, NMFS published a Final Rule (79 FR 53851), which concluded that this species did not warrant listing as endangered or threatened under the ESA.

3.8.2.3.36.2 Habitat and Geographic Range

The distribution is broad longitudinally, ranging from the east coast of Africa to the central Pacific and broad latitudinally ranging from the Red Sea and south of Japan in the northern hemisphere to halfway down both coastlines of Australia in the southern hemisphere. According to the International Union for Conservation of Nature and Natural Resources Species Account, *Porites nigrescens* has been recorded in American Samoa (Sheppard et al. 2008f). The species account also lists this species in the Northern Mariana Islands and the U.S. minor outlying islands.

Porites nigrescens has been reported to occupy lower reef slopes and lagoons protected from wave action at moderate depths ranging from 0.5 to 20 m (1.6 to 65.6 ft.).

3.8.2.3.36.3 Population and Abundance

Porites nigrescens has been reported as sometimes common. Where found, it can be a part of a locally abundant branching Poritiid assemblage (Australian Institute of Marine Science 2010; Phongsuwan and Brown 2007).

3.8.2.3.36.4 Predator-Prey Interactions

Porites is susceptible to crown-of-thorns seastar (*Acanthaster planci*) and corallivorous snail predation including predation of *Coralliphilia violacea* on both massive and branching forms. Massive Porites are susceptible, but not a preferred prey, of the predatory asteroid *Culcita novaeguineae*, and the butterflyfish *Chaetodon unimaculatus*.

3.8.2.3.36.5 Species-Specific Threats

Porites nigrescens is susceptible to the same suite of stressors that generally threaten corals. NMFS evaluated the population’s demographic, spatial structure, and vulnerability factors (77 FR 73220–73262) and identified elements that may threaten *Porites nigrescens*. These elements include high vulnerability to ocean warming, moderate vulnerability to disease and acidification, common generalized rangewide abundance, wide overall distribution (based on wide geographic distribution and moderate depth distribution), and inadequacy of existing regulatory mechanisms (79 FR 53851).

3.8.2.4 Taxonomic Group Descriptions

3.8.2.4.1 Phylum Cnidaria (e.g., Corals, Hydroids, Jellyfish)

There are over 10,000 marine species of corals, hydroids, and jellyfish worldwide (Appeltans et al. 2010). Members of this group are found throughout the Study Area at all depths. Hydroids are colonial animals that can have both flexible and rigid skeletons, but are not considered to be habitat-forming as corals are in creating reefs (Colin and Arneson 1995a; Gulko 1998). Jellyfish are motile as larvae, sessile as an intermediate colonial polyp stage, and motile as adults (Brusca and Brusca 2003). They are predatory at all stages and, like all Cnidaria, use tentacles equipped with stinging cells to capture prey (Castro and Huber 2000; University of California at Berkeley 2010a). Jellyfish are an important prey species to a range of organisms, including some sea turtles and some ocean sunfish (*Mola mola*) (Heithaus et al. 2002; James and Herman 2001).

The class Anthozoa includes anemones and corals (hard and soft). The individual unit of corals is a polyp, and most species occur as colonies of polyps. Corals can feed on plankton, which are small organisms that float with the currents, as well as other small organisms. Corals capture prey with tentacles that surround their mouth and are armed with stinging cells (Brusca and Brusca 2003). Reef-building corals occur in the photic zone (defined by the depth of light penetration) of coastal waters, typically shallower than approximately 650 ft. (200 m), and usually host symbiotic algae called zooxanthellae that provide nutrition to the corals as byproducts from photosynthesis (Veron and Stafford-Smith 2011; Castro and Huber 2000) and give the coral its color. The zooxanthellae receive shelter from the coral as well as carbon dioxide needed for photosynthesis. All corals feed on small planktonic organisms or dissolved organic matter, although some shallow-water corals derive most of their energy from their symbiotic algae (Dubinsky and Berman-Frank 2001). Most hard corals and some soft corals are habitat-forming (i.e., they form coral reefs) (Freiwald et al. 2004; Spalding et al. 2001; South Atlantic Fishery Management Council 1998). See Figure 3.8-2 through Figure 3.8-6 for information on the distribution and percent cover of corals surrounding Guam (and within Apra Harbor), Tinian, Saipan, and Farallon de Medinilla (FDM), as derived by satellite imagery by NOAA, near Guam, Apra Harbor, Saipan, and Tinian, respectively.

Many corals can reproduce either sexually or asexually. Some are hermaphrodites, meaning that they possess both male and female reproductive organs. Most species reproduce sexually by releasing eggs and sperm into the water (spawning), where fertilization occurs and larvae begin to develop. After larvae settle on an appropriate surface, the colony begins to grow (Boulon et al. 2005). Fragmentation is a common form of asexual reproduction in species with thin branches. During a storm, thin branches typically break off from a colony and form new colonies by attaching to a suitable surface (Richmond 1997). Although fragmentation helps maintain high growth rates, it reduces the reproductive potential of some coral species by delaying the production of eggs and sperm for years following the damage (Lirman 2000).

Predation on some coral genera, especially *Acropora, Montipora, Pocillopora*, and *Porites* in the Pacific, by many species of fish and invertebrates is a consistent threat to corals and has been identified for most coral life stages (Brainard et al. 2011). So far, 128 species of fish spread across 11 families have been found to prey on corals, with a third of the species relying on corals for more than 80 percent of their diet. Several experimental field studies have demonstrated that the distribution of corals was directly limited by predation of corallivorous fishes and invertebrates. Predation of corals by fishes and invertebrates is normally considered negative, but triggerfish and pufferfish have been shown to disperse coral fragments during feeding, potentially helping corals spread by asexual reproduction. Some predators also affect the distribution of corals by preferentially consuming coral species or forms that are the faster-growing and thereby superior competitors for space (e.g., *Acropora, Montipora, Pocillopora*, and branching *Porites*). For example, one study found that by reducing the growth of the superior competitor (e.g., *Montipora capitata*), predators allow the more slowly growing coral (*Porites compressa*) to prevail (Cox 1986).

Apart from a few exceptions, coral reefs in the Pacific Ocean are confined to the warm tropical and subtropical waters between 30 degrees (°) North (N) and 30° South (S). Over 400 scleractinian (stony corals) and hydrozoan coral species (hydrocorals), representing 22 families and 108 genera have, been identified from Guam and the Mariana Islands (Randall 2003). Of this total number, 377 are scleractinian species that occur within 20 families and 99 genera and 26 are hydrozoan species that occur within 2 families and 9 genera. About 70 percent of the coral fauna (281 species) contain zooxanthellae in their tissues and about 30 percent (122 species) are azooxanthellate, although several genera (contain both azooxanthellate and zooxanthellae species) (Randall 2003). Azooxanthellate obtain energy from detritus, zooplankton, and nekton they capture from the surrounding water. Since azooxanthellate corals do not depend on sunlight or a symbiotic existence with zooxanthellae, they can be found in deeper waters (National Marine Fisheries Service 2010b).

Deep-sea coral communities are prevalent throughout the Mariana Islands chain, and often form offshore reefs. Much like shallow-water corals, deep-sea corals are fragile, slow growing, and can survive for hundreds of years. In the Mariana Islands, gorgonians, while occurring at all depths, are the most commonly found corals in deep-sea communities. Gorgonian diversity and abundance increase below 30 m (98.4 ft.), especially in steep, cavernous, and current-swept areas, so that about 20 species are known between 30 and 60 m (98.4 and 196.9 ft.) (Paulay et al. 2003). Several of the gorgonian species listed have been encountered at diving depths only in caverns along the southern Orote Peninsula of Guam, especially the Blue Hole; these species are otherwise restricted to deeper water. In contrast, the much richer deep-water fauna remains poorly known. Gorgonians, the soft coral genera *Siphonogorgia* and *Dendronephthya*, and black corals become much more diverse and abundant below 60 m (196.9 ft.). Dredging and tangle net surveys (Eldredge 2003) have already revealed about 70 species of arborescent octocorals at 60 to 400 m (196.9 to 1,312.3 ft.) and many others surely remain to be collected.

There is evidence that overall coral reef habitat has declined in the Study Area, and this is used as a proxy for population decline in many species. Species that are particularly susceptible to bleaching, disease, and other threats are more susceptible to further decline; therefore, population decline is based on both the percentage of destroyed reefs and the percentage of critical reefs that are likely to be destroyed within 20 years (Wilkinson 2004).

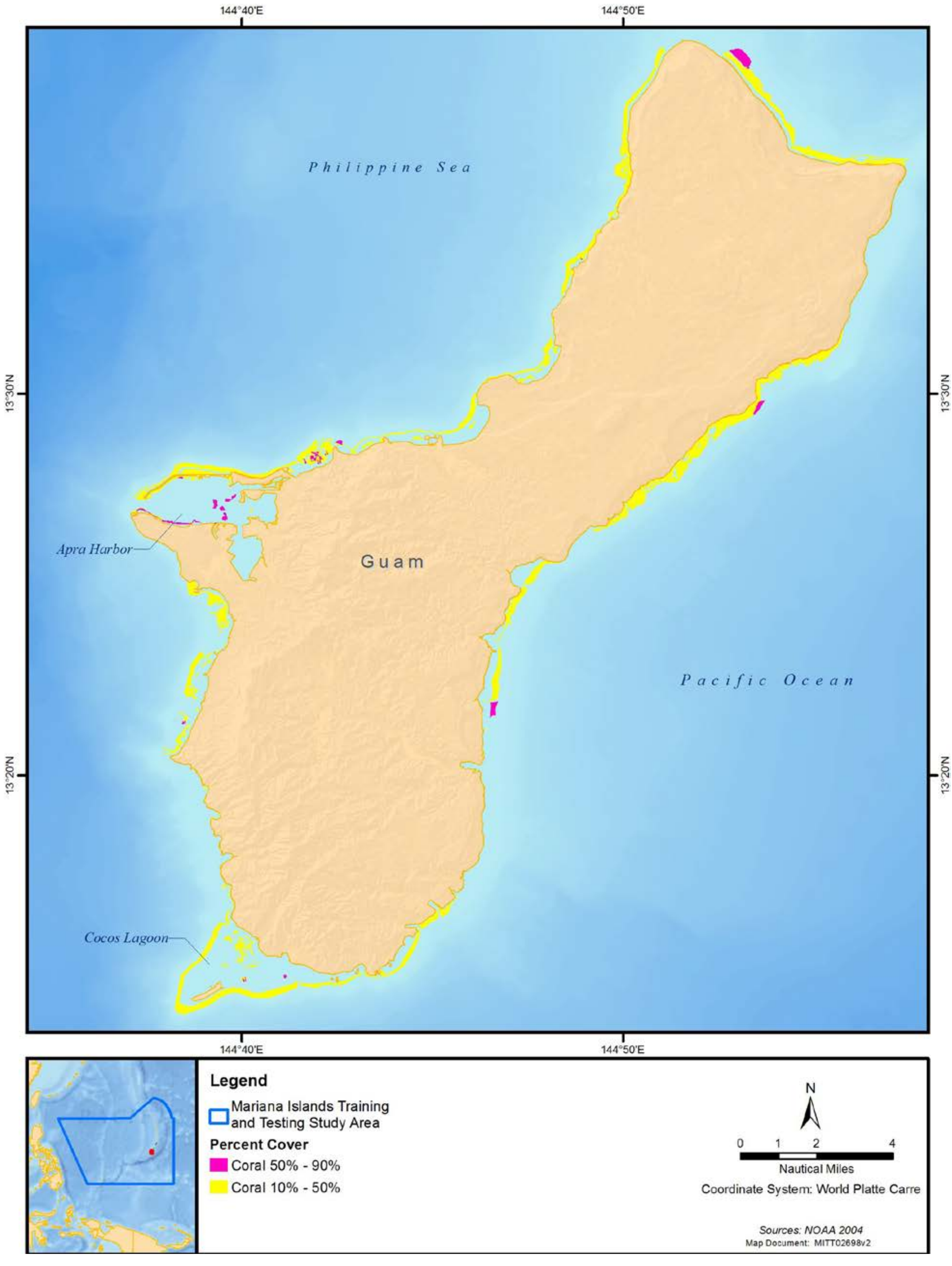


Figure 3.8-2: Distribution and Percent Cover of Corals Surrounding Guam

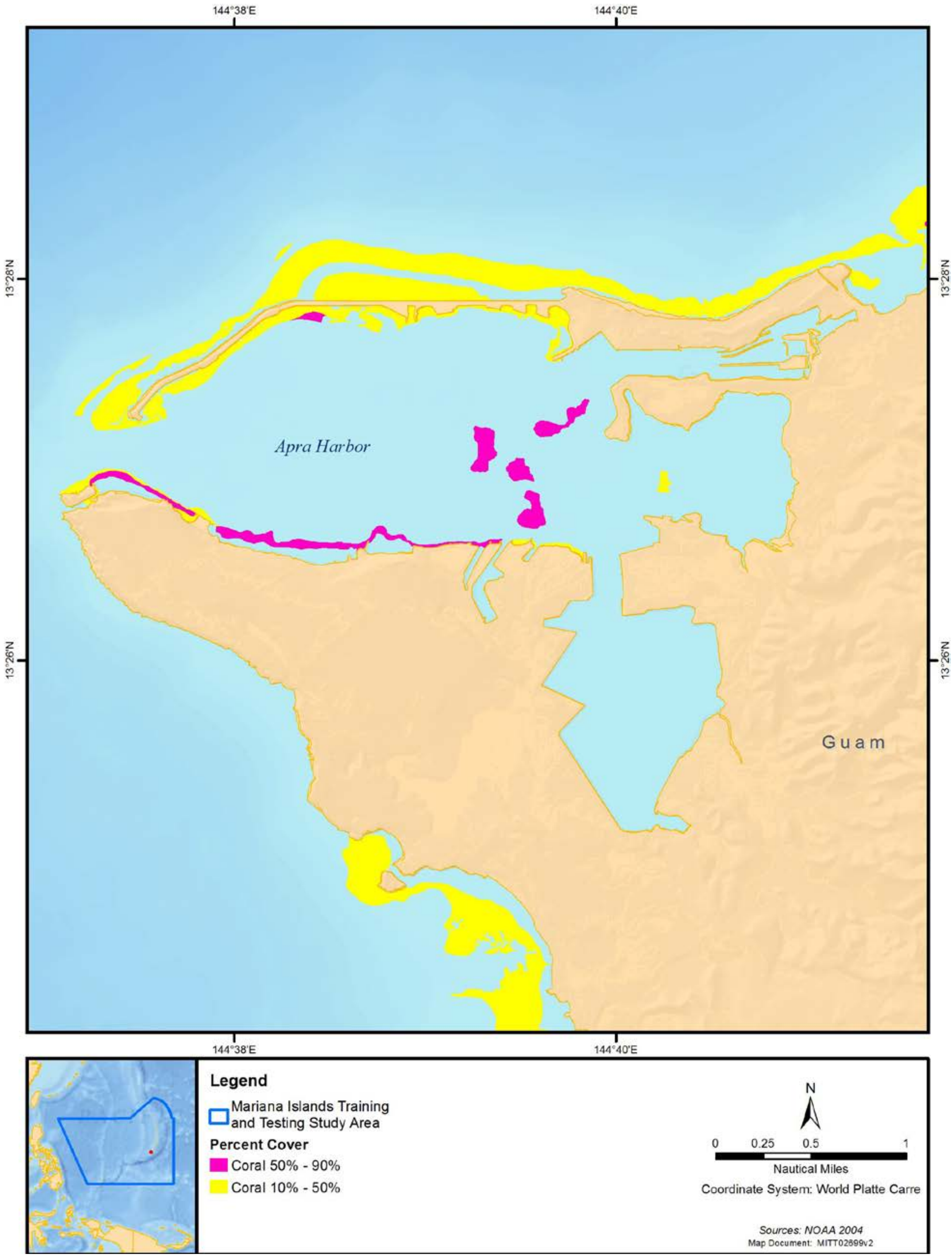


Figure 3.8-3: Distribution and Percent Cover of Corals Within Apra Harbor

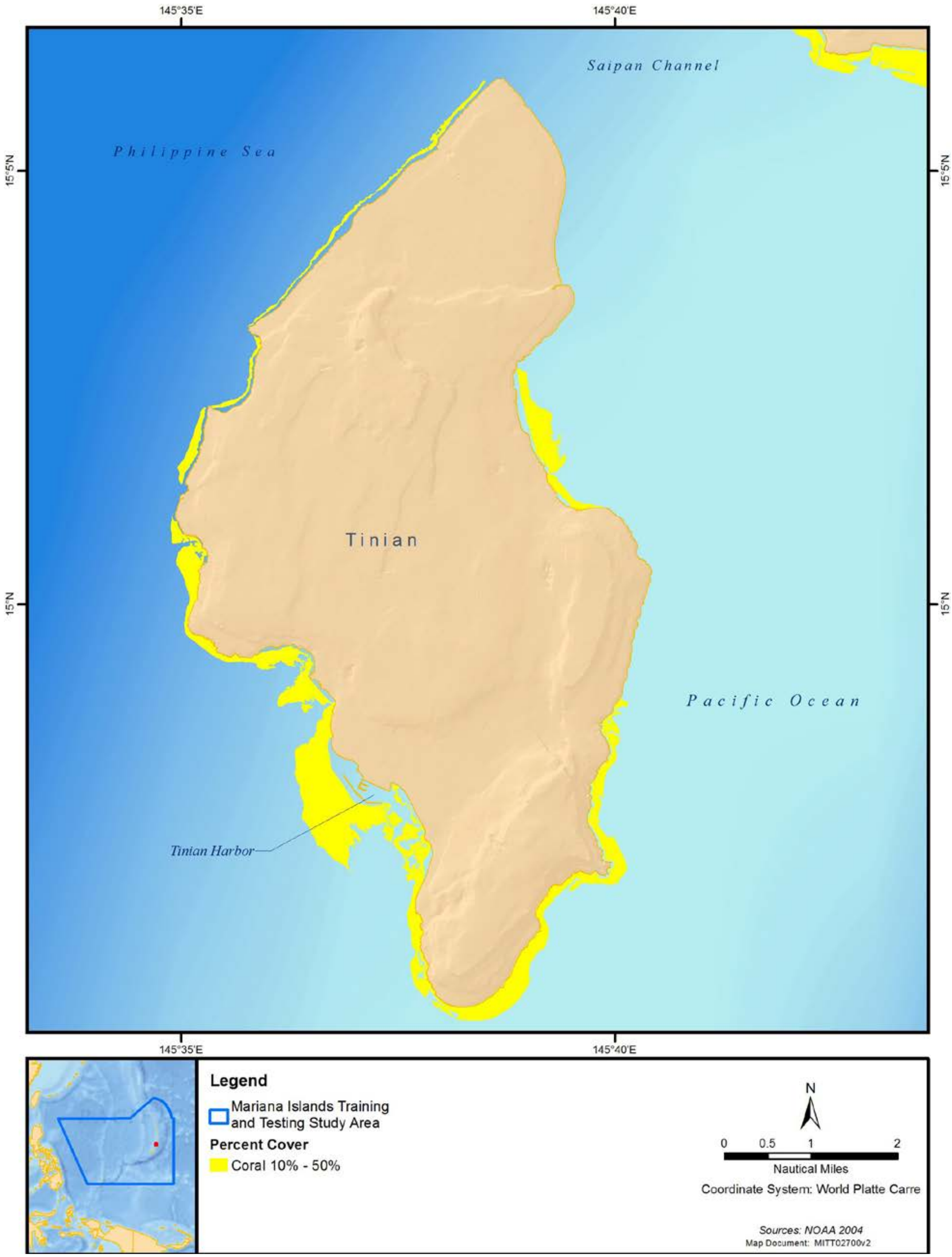


Figure 3.8-4: Distribution and Percent Cover of Corals Surrounding Tinian

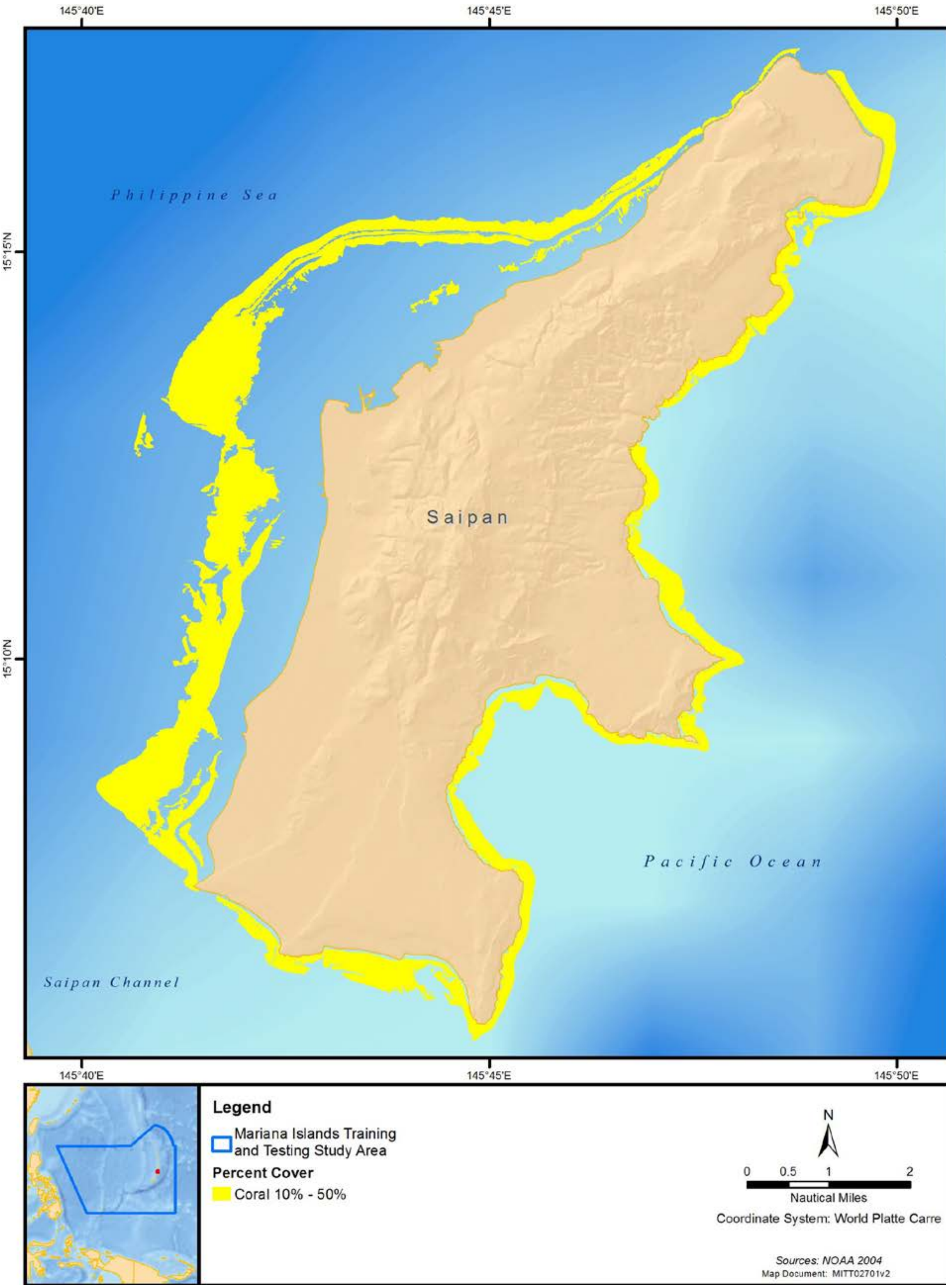


Figure 3.8-5: Distribution and Percent Cover of Corals Surrounding Saipan

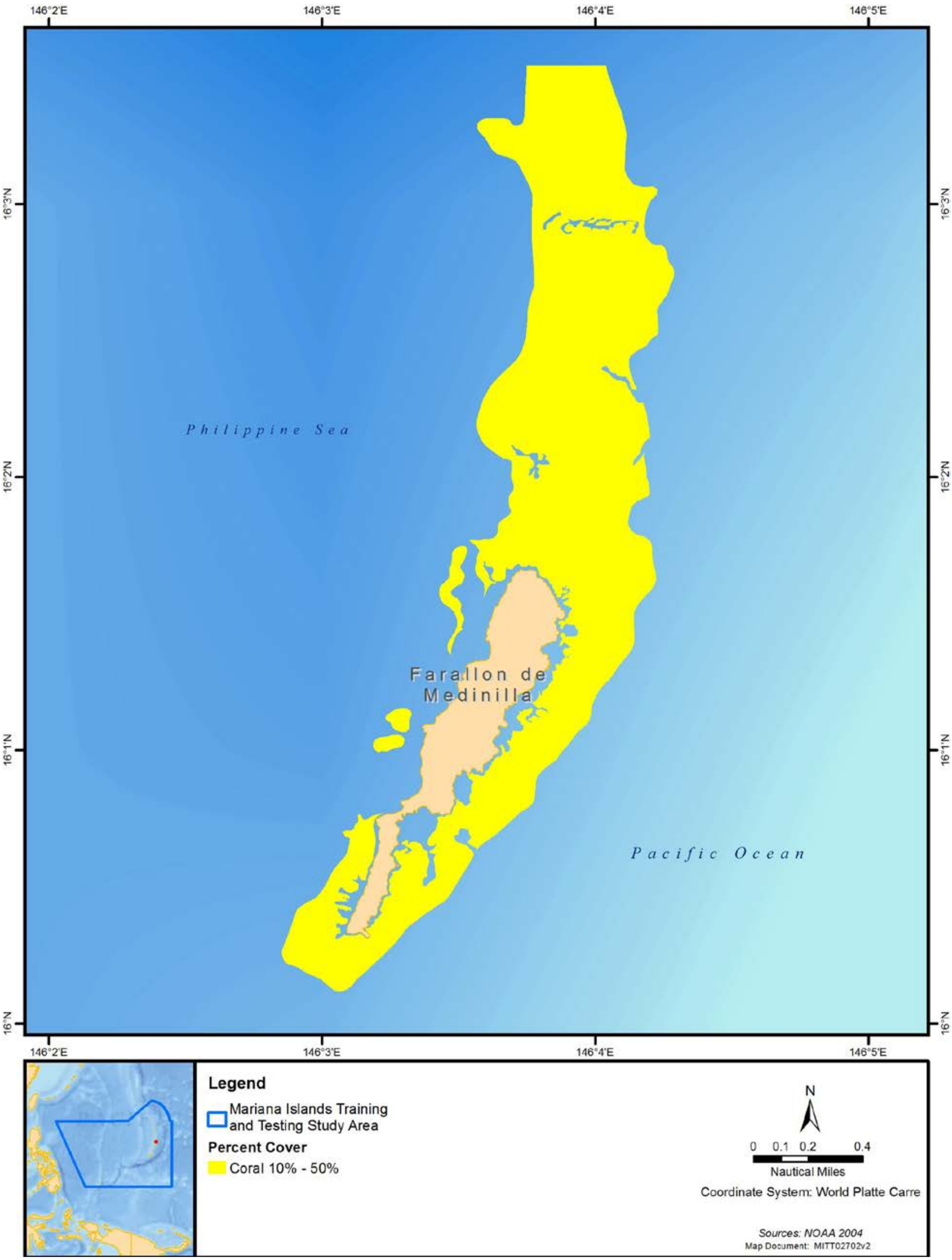


Figure 3.8-6: Distribution and Percent Cover of Corals Surrounding FDM

3.8.2.4.2 Phylum Platyhelminthes (Flatworms)

Flatworms include between 8,000 and 20,000 marine species worldwide (Appeltans et al. 2010; Castro and Huber 2000) and are the simplest form of marine worm (Castro and Huber 2000). The largest single group of flatworms are parasites commonly found in fishes, seabirds, and whales (Castro and Huber 2000; University of California Berkeley 2010b). The life history of parasitic flatworms plays a role in the regulation of populations for the marine vertebrates they inhabit. Ingestion by the host organism is the primary dispersal method for parasitic flatworms. As parasites, they are not typically found in the water column, outside of a host organism. The remaining groups are non-parasitic carnivores, living without a host. Flatworms are found throughout the Study Area living on rocks in tidepools and reefs, within the top layer of sandy areas, or planktonic. Eighty-eight species of flatworms have been identified from surveys and from literature records in and around Guam (Newman et al. 2003); however, due to the difficulty in taxonomic determinations, the authors believe there may be in excess of 100 species.

3.8.2.4.3 Phylum Nemertea (Ribbon Worms)

Ribbon worms include approximately 1,000 marine species worldwide (Appeltans et al. 2010). Ribbon worms, with their distinct gut and mouth parts, are more complex than flatworms (Castro and Huber 2000). Organisms in this phylum are bottom-dwelling, predatory marine worms that are equipped with a long extension from the mouth (i.e., a proboscis) that helps them capture food (Castro and Huber 2000). Some species are also equipped with a sharp needle-like structure that delivers poison to kill prey. Ribbon worms occupy an important place in the marine food web as prey for a variety of fish and invertebrates and as a predator of other bottom-dwelling organisms, such as worms and crustaceans (Castro and Huber 2000). Some ribbon worms occupy the inside of the mantle of molluscs where they feed on the waste products of their host (Castro and Huber 2000). Eight species of ribbon worms have been found within the Study Area (Paulay 2003a).

3.8.2.4.4 Phylum Nematoda (Round Worms)

Round worms include over 5,000 marine species, though this number may be significantly underestimated (Appeltans et al. 2010). Round worms are small and cylindrical, and are abundant in sediments and can also be found in host organisms as parasites (Castro and Huber 2000). Round worms are one of the most widespread marine invertebrates, with population densities of up to one million organisms per 11 square feet ($ft.^2$) (1.02 square meters [m^2]) of mud (Levinton 2009). This group has a variety of food preferences, including algae, small invertebrates, annelid worms, and organic material from sediment. Like parasitic flatworms, parasitic nematodes provide important ecosystem services by regulating populations of other marine organisms by causing illness or mortality in less viable organisms. Species in the family Anisakidae infect marine fish, and may cause illness in humans if fish are consumed raw without proper precautions. Round worms are found throughout the Study Area.

3.8.2.4.5 Phylum Annelida (Segmented Worms)

Segmented worms include approximately 12,000 marine species worldwide in the phylum Annelida, although most marine forms are in the class Polychaeta (Appeltans et al. 2010). Segmented worms are the most physiologically complex group of marine worms with a well-developed respiratory and gastrointestinal system (Castro and Huber 2000). Different species of segmented worms may be highly mobile or burrow in the seafloor (Castro and Huber 2000). Most segmented worms are predators; others are scavengers, deposit feeders, filter feeders, or suspension feeders of sand, sediment, and water (Hoover 1998c). The variety of feeding strategies and close connection to the seafloor make Annelids an integral part of the marine food web (Levinton 2009). Burrowing in the seafloor and agitating the sediment increases the oxygen content of seafloor sediments and makes important buried nutrients available to other organisms. This ecosystem service allows bacteria and other organisms, which are also an important part of the food web, to flourish on the seafloor. Segmented worms are found throughout the Study Area inhabiting rocky, sandy, and muddy areas of the seafloor. These worms also colonize on corals, vessel hulls, docks, and floating debris.

3.8.2.4.6 Phylum Mollusca (e.g., Squid, Bivalves, Sea Snails, Chitons)

There are approximately 27,000 marine species that are classified in the Phylum Mollusca worldwide (Appeltans et al. 2010). Gastropods (e.g., sea snails), bivalves (e.g., mussels), cephalopods (e.g., squid), and chitons (polyplacophorans) are marine invertebrates that possess a muscular organ called a foot, which is used for mobility (Castro and Huber 2000). 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 and Huber 2000; Colin and Arneson 1995c). Clams, mussels, and other bivalves feed on suspended food particles (e.g., phytoplankton, detritus) (Castro and Huber 2000). Chitons, sea snails, and slugs use rasping tongues, known as radula, to scrape food (e.g., algae) off rocks (Castro and Huber 2000; Colin and Arneson 1995c). 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 and Huber 2000; Hoover 1998c; Western Pacific Regional Fishery Management Council 2001). Octopuses mostly prey on fish, shrimp, eels, and crabs (Wood and Day 2005).

Creel surveys (estimates of local fisheries catch data) have shown that the main species collected within the shore-based harvesting are octopus (*Octopus cyanea, O. ornatus*) and topsnail (*Tectus niloticus*). Important species of Mollusca, as indicated by creel surveys of boat-based harvesting show that the highest catches are of octopus (*Octopus cyanea*, *O. ornatus*, and *O. teuthoides*), topsnail (*Trochus niloticus*), giant spider conch (*Lambis truncata*), and bigfin reef squid (*Sepioteuthis lessoniana*) (Burdick et al. 2008).

3.8.2.4.7 Phylum Arthropoda (e.g., Shrimp, Crab, Lobster, Barnacles, Copepods)

Shrimp, crabs, lobsters, barnacles, and copepods are animals with skeletons on the outside of their body (exoskeleton) (Castro and Huber 2000), and are classified as crustaceans in the Phylum Arthropoda, which also includes insects and arachnids. Shrimp, crabs, and lobsters are typically carnivores, omnivorous predators, or scavengers, preying on molluscs (primarily gastropods), other crustaceans, echinoderms, small fish, algae, and sea grass (Waikiki Aquarium 2009a, b, c; Western Pacific Regional Fishery Management Council 2009). Barnacles and copepods filter algae and other small organisms from the water (Levinton 2009).

Important recreational species of Crustacea, as indicated by creel surveys of the shore-based fishery, are lobster (*Panulirus penicillatus*), slipper lobster (*Parribacus antarticus*) and crab (*Scylla serrate*). The important harvested species of the boat-based fishery are lobster (*Panulirus penicillatus, P. versicolor*), and slipper lobster (*Parribacus antarticus*) (Burdick et al. 2008).

3.8.2.4.8 Phylum Echinodermata (e.g., Sea Stars, Sea Urchins, Sea Cucumbers)

Organisms in this phylum include over 6,000 marine species, such as sea stars, sea urchins, and sea cucumbers (Appeltans et al. 2010). Asteroids (e.g., sea stars), sechinoids (e.g., sea urchins), holothuroids (e.g., sea cucumbers), ophuiroids (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 (Castro and Huber 2000). Echinoderms occur at all depth ranges from the intertidal zone to the abyssal zone and are almost exclusively benthic (living on the sea floor). Most echinoderms have separate sexes, but unisexual forms occur among the sea stars, sea cucumbers, and brittle stars. Many species have external fertilization, producing planktonic larvae, but some brood their eggs, never releasing free-swimming larvae (Colin and Arneson

1995b). Many echinoderms are either scavengers or predators on organisms that do not move, such as algae, stony corals, sponges, clams, and oysters (Hoover 1998b), although some also predate on other species of seastars. Some species, however, filter food particles from sand, mud, or water.

Important commercial, ecological, and recreational species in the shore-based fishery of Guam are the sea urchins (*Tripneustes gratilla* and *Toxipneustes pilolus*) (Burdick et al. 2008) and sea cucumbers (Kinch et al. 2008).

3.8.2.4.9 Phylum Porifera (Sponges)

Sponges include over 8,000 marine species worldwide, and are classified in the Phylum Porifera (Appeltans et al. 2010). Sponges are bottom-dwelling, multi-cellular animals that can be best described as an aggregation of cells that perform different functions. Sponges are largely sessile (not mobile), except for their larval stages, and are common throughout the Study Area at all depths. This filtering process is an important coupler of pelagic and benthic processes (Perea-Blázquez et al. 2012). Sponges reproduce both sexually and asexually. Water flowing through the sponge provides food and oxygen and removes wastes (Castro and Huber 2000; Collins and Waggoner 2006). Many sponges form calcium carbonate or silica spicules or bodies embedded in cells to provide structural support (Castro and Huber 2000). Sponges provide homes for a variety of animals, including shrimp, crabs, barnacles, worms, brittle stars, holothurians, and other sponges (Colin and Arneson 1995d). Over 100 species of siliceous sponges (Class Demospongiae) and 4 species of the calcareous sponges (Class Calcarea) have been identified from the marine waters of the Mariana Islands (Kelly et al. 2003).

3.8.2.4.9.1 Kingdom Protozoa (e.g., Foraminifera, Radiolarians, Ciliates)

Foraminifera, radiolarians, and ciliates are minute singled-celled organisms, sometimes forming colonies of cells, belonging to the Kingdom Protozoa (Castro and Huber 2000). They are found in the water column and seafloor of the world's oceans. Forminifera form diverse and intricate shells out of calcium carbonate (Wetmore 2006). The shells of formanifera that live in the water column eventually sink to the deep seafloor, forming sediments known as formaminiferan ooze. Four new species of foraminifera were recently discovered in the Challenger Deep at a depth of over 10,800 m (35,400 ft.) in the Marianas Trench (Gooday et al. 2008). Foraminifera feed on diatoms and other small organisms. Their predators include copepods and other zooplankton. Radiolarians are microscopic organisms that form shells made of silica. Radiolarian ooze covers large areas of the ocean floor (Castro and Huber 2000; Wetmore 2006). Ciliates are protozoans with small hair-like extensions that are used to feed and move around. Over 300 species of the clade Foraminifera occur in the substrate and marine waters surrounding Guam (Richardson and Clayshulte 2003). However, while species of protozoans have been identified within the MITT Study Area, direct measurements of abundance are not readily available.

3.8.3 Environmental Consequences

This section presents the analysis of potential impacts on marine invertebrates, from implementation of the project alternatives, including the No Action Alternative, Alternative 1, and Alternative 2. U.S. Department of the Navy (Navy) training and testing activities are evaluated for their potential impact on marine invertebrates in general, by taxonomic groups, and in detail for species listed under the ESA (Section 3.8.2, Affected Environment).

The stressors vary in intensity, frequency, duration, and location within the Study Area. The stressors applicable to marine invertebrates in the study area and analyzed below include the following:

- Acoustic (sonar and other active acoustic sources; underwater explosives; swimmer defense airguns; weapons firing, launch and impact noise; aircraft noise; and vessel noise)
- Energy Stressors (electromagnetic devices)
- Physical disturbance and strike (vessels, in-water devices, military expended materials, and seafloor devices)
- Entanglement (Fiber optic cables and guidance wires, and decelerators/parachutes)
- Ingestion (munitions and military expended materials other than munitions)
- Secondary (impacts associated with sediments and water quality)

The specific analysis of the training and testing activities presented in this section considers the relevant components and associated data within the geographic location of the activity (see Tables 2.8-1 through 2.8-4) and the resource.

3.8.3.1 Acoustic Stressors

Assessing whether sounds may disturb or injure an animal involves understanding the characteristics of the acoustic sources, the animals that may be near the sound, and the effects that sound may have on the physiology and behavior of those animals. The methods used to predict acoustic effects on invertebrates build upon the conceptual framework for assessing effects from sound-producing activities (Appendix H.1, Conceptual Framework for Assessing Effects from Sound-Producing Activities). Categories of potential impacts are direct trauma, hearing loss, auditory masking, behavioral reactions, and physiological stress. Little information is available on the potential impacts on marine invertebrates' exposure to sonar, explosions, and other sound-producing activities. Most studies focus on squid or crustaceans, and the consequences of exposures to broadband impulse air guns typically used for seismic exploration, rather than on sonar or explosions.

Direct trauma and mortality may occur due to the rapid pressure changes associated with an explosion. Most invertebrates lack air cavities that would respond to pressure waves, which typically causes the most damage in fish or marine mammals. Marine invertebrates could also be displaced, or in the case of delicate coral polyps or structures, damaged, by a shock wave.

To experience hearing impacts, masking, behavioral reactions, or physiological stress, a marine invertebrate must be able to sense sound. Marine invertebrates are likely only sensitive to water particle motion caused by nearby low-frequency sources, and likely do not hear or feel distant or mid- and high-frequency sounds. Lovel et al. (2005) determined hearing sensitivity in prawns to sounds between 100 Hz and 3 kHz (though the threshold levels were all above 100 dB re 1 μPa). No damage to statocysts (a sensory receptor in some aquatic invertebrates) and no impacts on crustacean balance (a function of the statocyst) were observed in crustaceans repeatedly exposed to high-intensity airgun firings (Christian et al. 2003; Payne et al. 2007). The limited information suggests that marine invertebrate statocysts may be resistant to impulse sound impacts, but that the impact of long-term or non-impulse sound exposures is undetermined.

Masking occurs when a sound interferes with an animal's ability to detect other biologically relevant sounds in its environment. Little is known about how marine invertebrates use sound in their environment. Some studies have shown that crab and coral larvae and post-larvae may use nearby reef sounds when in their settlement phase (Jeffs et al. 2003; Radford et al. 2007; Stanley et al. 2010; Vermeij et al. 2010), although it is unknown what component of reef noise is used. Larvae likely sense particle motion of nearby sounds, limiting their reef noise detection range (less than 328 ft. [100.01 m]) (Vermeij et al. 2010). Anthropogenic sounds could mask important acoustic cues, affecting detection of settlement cues or predators, potentially affecting larval settlement patterns or survivability in highly modified acoustic environments (Simpson et al. 2011). Low-frequency sounds could interfere with perception of low-frequency rasps or rumbles among crustaceans, although these are often already obscured by ambient noise (Patek et al. 2009). Sonar is not used in areas where ESA-listed coral species are known to occur.

Studies of invertebrate behavioral responses to sound have focused on responses to impulse sound. Some caged squid showed strong startle responses, including inking, when exposed to the first shot of broadband sound from a nearby seismic airgun (sound exposure level of 163 dB re 1 μPa^2-s), but strong startle responses were not seen when sounds were gradually increased (McCauley et al. 2000a, b). Slight increases in behavioral responses, such as jetting away or changes in swim speed, were observed at received levels exceeding 145 dB re 1 μPa^2-s (McCauley et al. 2000a, b). Other studies have shown no observable response by marine invertebrates to sounds. Snow crabs did not react to repeated firings of a seismic airgun (peak received sound level was 201 dB re 1 µPa) (Christian et al. 2003) and squid did not respond to killer whale echolocation clicks (higher frequency signals ranging from 199 to 226 dB re 1 µPa) (Wilson et al. 2007). Krill did not respond to a research vessel approaching at 2.7 knots (source level below 150 dB re 1 µPa) (Brierley et al. 2003). Distraction may be a consequence of some sound exposures. Hermit crabs were shown to delay reaction to an approaching visual threat when exposed to continuous noise, putting them at increased risk of predation (Chan et al. 2010).

There is some evidence of possible stress effects on invertebrates from long-term or intense sound exposure. Captive sand shrimp exposed to low-frequency noise (30 to 40 dB above ambient) continuously for 3 months demonstrated decreases in both growth rate and reproductive rate (Lagardère 1982). Sand shrimp showed lower rates of metabolism when kept in quiet, soundproofed tanks than when kept in tanks with typical ambient noise (Lagardère and Régnault 1980). The effect of long-term (multiple years), intermittent sound exposure was examined in a statistical analysis of recorded catch rate of rock lobster and seismic airgun activity (Parry and Gason 2006). No correlation was found between catch rate and seismic airgun activity, implying no long-term population impacts from intermittent anthropogenic sound exposure over long periods.

Because research on the consequences of exposing marine invertebrates to anthropogenic sounds is limited, qualitative analyses described below were conducted to determine the effects of the following acoustic stressors on marine invertebrates within the Study Area: non-impulse sources (including sonar other active acoustic sources) and impulse acoustic sources (including explosives, swimmer defense airguns, and weapons firing).

3.8.3.1.1 Impacts from Sonar and Other Active Acoustic Sources

Sources of non-impulse underwater sound during testing and training activities include vessel noise (including surface ships and small boats), aircraft overflight noise (i.e., fixed-wing and rotary-wing aircraft), and sonar, and other active acoustic sources.

Many ongoing and proposed training and testing activities within the Study Area involve maneuvers by various types of surface ships, boats, and submarines (collectively referred to as vessels). Activities involving vessel movements occur intermittently, and are variable in duration, ranging from a few hours up to two weeks. Navy traffic is heaviest near the Navy port facilities and training areas within the Mariana Islands Range Complex (MIRC). Additionally, a variety of smaller craft could be operated within the Study Area. Surface combatant ships and submarines are designed to be quiet to evade enemy detection. Other Navy ships and small craft have higher source levels, similar to equivalently sized commercial ships and private vessels. Ship noise tends to be low-frequency and broadband.

Fixed and rotary-wing aircraft are used for a variety of training and testing activities throughout the Study Area. Airborne broadband noise from aircraft can be transmitted through the air-water interface, though much of energy is lost at the sea-air interface. Underwater sounds from aircraft are strongest just below the surface and directly under the aircraft. Sonar and other active acoustic sources emit sound waves into the water to detect objects, safely navigate, and communicate. These sources may emit low-, mid-, high-, or very-high-frequency sounds at various sound pressure levels.

Most marine invertebrates do not have the capability to sense sound; however, some may be sensitive to nearby low-frequency and possibly lower-mid-frequency sounds, such as some active acoustic sources or vessel noise. As described in Section 3.8.2.1 (Invertebrate Hearing and Vocalization), invertebrate species detect sounds through particle motion, which diminishes rapidly from the sound source. Most activities using sonar or other active acoustic sources would be conducted in deepwater, offshore areas of the Study Area and are not likely to affect most invertebrate species, including ESA-listed coral species. Furthermore, invertebrate species have their best hearing sensitivity below 1 kHz and would not be capable of detecting the majority of sonars and other acoustic sources used in the Study Area.

The relatively low sound pressure level beneath the water surface caused by aircraft overflights is likely not detectable by most marine invertebrates. For example, the sound pressure level from an H-60 helicopter hovering at 50 ft. is estimated to be about 125 dB re 1 µPa at 1 m below the surface, a sound pressure lower than other sounds to which marine invertebrates have shown no reaction (see Section 3.8.3.1, Acoustic Stressors). Therefore, impacts due to aircraft overflight noise are not expected.

3.8.3.1.1.1 No Action Alternative

Training Activities

Under the No Action Alternative, marine invertebrates would be exposed to low-, mid-, and high-frequency sonar; vessel noise; and aircraft overflight noise during training activities. These activities could occur throughout the open ocean areas of the Study Area. Certain portions of the Study Area, such as areas near Navy ports and airfields, installations, and training ranges, are used more heavily by vessels and aircraft than other portions of the Study Area. A more detailed description of these activities, the number of activities, and their proposed locations is provided in Table 2.8-1.

Species that do not occur within these specified areas would not be exposed to low-, mid-, and high-frequency sonar; vessel noise; and aircraft overflight noise during training activities. Species that do occur within the areas listed above—including ESA-listed coral species—would have the potential to be exposed to sonar, vessel, and aircraft noise. Human-induced physical damage was considered by NMFS to be a “negligible to low-importance” threat to coral species and was not cited as a factor when considering the ESA listing of coral species.

Corals throughout the Study Area may be exposed to non-impulse sounds generated by sonar and other active acoustic sources, vessels, and aircraft during training. Most underwater acoustic sources would not be used in the shallow waters (less than 100 ft. [30 m]) where ESA-listed coral species are known to exist. There is no evidence that corals or coral larvae are sensitive to distant non-impulse sounds, although larvae may sense particle motion from close sounds. Sound from training activities is intermittent or transient, or both, and will not commonly occur close enough to reefs to interfere with larval perception of reef noise.

Most marine invertebrates will not sense mid- or high-frequency sounds, but some individual marine invertebrates may sense nearby low-frequency sounds such as vessel noise, aircraft overflight noise (transmitted through the air-water interface), and lower-frequency sonar. Because most non-impulse sound sources are transient or intermittent, or both, any responses are likely to be short-term behavioral responses or brief masking. Non-impulse sounds may impact individual marine invertebrates and groups of marine invertebrates close to a sound source, but they are unlikely to impact populations or subpopulations.

Pursuant to the ESA, sonar and other active acoustic sources associated with training activities as described under the No Action Alternative may affect ESA-listed coral species.

Testing Activities

Under the No Action Alternative, marine invertebrates could be exposed to low-, mid-, and high-frequency acoustic sources used during testing activities. Testing activities potentially using non-impulse acoustic sources under the No Action Alternative include the North Pacific Acoustic Lab Philippine Sea Experiment (Table 2.4-4). In 2018, research vessels, acoustic test sources, side scan sonar, ocean gliders, the existing moored acoustic tomographic array and distributed vertical line array, and other oceanographic data collection equipment will be used to collect information on the ocean environment and sound propagation.

ESA-listed coral species are not expected to be present in the portion of the Study Area where the Philippine Sea Experiment is conducted. Underwater acoustic sources would not be used in the shallow waters (less than 100 ft. [30 m]) where ESA-listed coral species are known to exist. There is no evidence that corals or coral larvae are sensitive to distant non-impulse sounds. Sound from testing activities is intermittent or transient, or both, and will not commonly occur close enough to reefs to interfere with larval perception of reef noise.

Pursuant to the ESA, sonar and other active acoustic sources associated with testing activities as described under the No Action Alternative may affect ESA-listed coral species.

3.8.3.1.1.2 Alternative 1

Training Activities

Under Alternative 1, marine invertebrates would be exposed to low-, mid-, and high-frequency sonar and other acoustic sources, vessel noise, and aircraft overflight noise during training activities. The number of annual training activities that produce in-water noise from the use of sonar and other active acoustic sources under Alternative 1 would increase as indicated in Table 3.0-8 of Chapter 3 (Affected Environment and Environmental Consequences), over the No Action Alternative. However, the vast majority of activities that produce non-impulse sound occur greater than 3 nautical miles (nm) from shore within the Study Area. As the depth of the water drops quickly as you move away from the inshore reefs, the density of benthic invertebrates drops. Invertebrates that are in these locations could be exposed to non-impulse acoustic sources. However, because most non-impulse sound sources would be transient or intermittent, or both, any responses would likely be short-term behavioral responses or brief masking. Non-impulse sounds could impact individual marine invertebrates and groups of marine invertebrates close to a sound source, but they are unlikely to impact populations or subpopulations.

Corals throughout the Study Area may be exposed to non-impulse sounds generated by sonar and other acoustic sources, vessels, and aircraft during training under Alternative 1. However, the vast majority of underwater acoustic sources would not be used in the shallow waters (less than 100 ft. [30 m]) where the majority of ESA-listed coral species are known to exist. The ESA-listed coral species that are found in deeper waters may be exposed to non-impulsive sounds, which could impact individual marine invertebrates and groups of marine invertebrates close to the sound source, but they are unlikely to impact populations or subpopulations. Sound from training activities is intermittent or transient, or both, and will not commonly occur close enough to reefs or ESA-listed coral species to interfere with larval perception of reef noise. Continuous noise from training activities (e.g., vessel noise) could mask reef noise. If this noise source overlapped with the larval settlement period, recruitment of larvae onto a reef habitat may be altered.

Pursuant to the ESA, sonar and other active acoustic sources associated with training activities as described under Alternative 1 may affect ESA-listed coral species.

Testing Activities

Under Alternative 1, marine invertebrates could be exposed to low-, mid-, and high-frequency sonar and other active acoustic sources, vessel noise, and aircraft overflight noise during testing activities. The number of testing activities that produce in-water noise from the use of sonar and other active acoustic sources under Alternative 1 would increase from the No Action Alternative. A detailed description of these activities, the number of activities, and their proposed locations in the Study Area are presented in Tables 2.8-2 through 2.8-4 of Chapter 2 (Description of Proposed Action and Alternatives). Testing activities using sonar and other active acoustic sources include:

- Anti-Submarine Warfare Tracking Test – Maritime Patrol Aircraft (Sonobuoys)
- Anti-Submarine Warfare Torpedo Test (Maritime Patrol Aircraft)
- Ship Signature Testing
- Torpedo Testing
- Countermeasure Testing
- At-Sea Sonar Testing
- Pierside Integrated Swimmer Defense
- ASW Mission Package Testing
- Mine Countermeasure (MCM) Mission Package Testing
- North Pacific Acoustic Lab Philippine Sea 2018–19 Experiment (Deep Water)

Annual testing activities that produce in-water sound from the use of sonar and other active acoustic sources under Alternative 1 would increase as indicated in Tables 2.8-2 through 2.8-4 and Table 3.0-8 of Chapter 3 (Affected Environment and Environmental Consequences), over no usage under the No Action Alternative. Similarly, aircraft events increase (from 0 under the No Action Alternative, to 320 under Alternative 1 [Table 3.0-14]) as do activities involving vessels. However, the vast majority of activities that produce non-impulse sound occur farther than 3 nm from shore within the Study Area. Water depth decreases abruptly a relatively short distance from shore; correspondingly, the density of benthic invertebrates decreases with the increasing water depth. Invertebrates that are in these locations could be exposed to non-impulse acoustic sources. However, because most non-impulse sound sources would be transient or intermittent, or both, any responses would likely be short-term behavioral responses or brief masking. Non-impulse sounds could impact individual marine invertebrates and groups of marine invertebrates close to a sound source, but they are unlikely to impact populations or subpopulations.

Corals throughout the Study Area could be exposed to non-impulse sounds generated by sonar and other acoustic sources, vessels, and aircraft during testing. There is no evidence that corals or coral larvae are sensitive to distant non-impulse sounds, although larvae may sense particle motion from close sounds. Sound from testing activities would be intermittent or transient, or both, and would not commonly occur close enough to reefs to interfere with larval perception of reef noise. Non-intermittent noise from testing activities (e.g., vessel noise) could mask reef noise. If non-intermittent noise sources overlap in time with the larval settlement period, recruitment of larvae onto a reef habitat may be affected.

Pursuant to the ESA, sonar and other active acoustic sources associated with testing activities as described under Alternative 1 may affect ESA-listed coral species.

3.8.3.1.1.3 Alternative 2

Training Activities

Under Alternative 2, marine invertebrates would be exposed to low-, mid-, and high-frequency sonar and other acoustic sources, vessel noise, and aircraft overflight noise during training activities. The number of annual training activities that produce in-water noise from the use of sonar and other active acoustic sources under Alternative 2 would as indicated in Table 3.0-8 of Chapter 3 (Affected Environment and Environmental Consequences), over Alternative 1. However, the vast majority of activities that produce non-impulse sound occur greater than 3 nm from shore within the Study Area. As the depth of the water drops quickly as you move away from the inshore reefs, the density of benthic invertebrates drops. Invertebrates that are in these locations could be exposed to non-impulse acoustic sources. However, because most non-impulse sound sources would be transient or intermittent, or both, any responses would likely to be short-term behavioral responses or brief masking. Non-impulse sounds could impact individual marine invertebrates and groups of marine invertebrates close to a sound source, but they are unlikely to impact populations or subpopulations. Continuous noise from training activities (e.g., vessel noise) could mask reef noise. If this noise source overlapped with the larval settlement period, recruitment of larvae onto a reef habitat may be altered.

Corals throughout the Study Area may be exposed to non-impulse sounds generated by sonar and other acoustic sources, vessels, and aircraft during training under Alternative 2. However, the vast majority of underwater acoustic sources would not be used in the shallow waters (less than 100 ft. [30 m]) where the majority of the ESA-listed coral species are known to exist. The ESA-listed coral species that are found in deeper waters may be exposed to non-impulsive sounds that could impact individual marine invertebrates and groups of marine invertebrates close to the sound source, but they are unlikely to impact populations or subpopulations. Sound from training activities is intermittent or transient, or both, and will not commonly occur close enough to reefs or ESA-listed coral species to interfere with larval perception of reef noise.

Pursuant to the ESA, sonar and other active acoustic sources associated with training activities as described under Alternative 2 may affect ESA-listed coral species.

Testing Activities

Under Alternative 2, marine invertebrates would be exposed to low-, mid-, and high-frequency sonar and other acoustic sources, vessel noise, and aircraft overflight noise during testing activities. The number of testing activities that produce in-water noise from the use of sonar and other active acoustic sources under Alternative 2 would increase from the No Action Alternative. A detailed description of these activities, the number of activities, and their proposed locations are presented in Tables 2.8-2 through 2.8-4 of Chapter 2 (Description of Proposed Action and Alternatives). Testing activities using sonar and other active acoustic sources include:

- Anti-Submarine Warfare Tracking Test – Maritime Patrol Aircraft (Sonobuoys)
- Anti-Submarine Warfare Torpedo Test (Maritime Patrol Aircraft)
- Ship Signature Testing

- Torpedo Testing
- Countermeasure Testing
- At-Sea Sonar Testing
- Pierside Integrated Swimmer Defense
- ASW Mission Package Testing
- Mine Countermeasure (MCM) Mission Package Testing
- North Pacific Acoustic Lab Philippine Sea 2018–19 Experiment (Deep Water)

Annual testing activities that produce in-water noise from the use of sonar and other active acoustic sources under Alternative 2 would increase as indicated in Table 2.8-2 through 2.8-4 and Table 3.0-8 of Chapter 3 (Affected Environment and Environmental Consequences), over no usage under the No Action Alternative. Similarly, aircraft events increase (from 0 under the No Action Alternative, to 362 under Alternative 2 [Table 3.0-14]) as do activities involving vessels. However, the vast majority of activities that produce non-impulse sound occur farther than 3 nm from shore within the Study Area. Water depth decreases abruptly a relatively short distance from shore; correspondingly, the density of benthic invertebrates decreases with the increasing water depth. Invertebrates that are in these locations could be exposed to non-impulse acoustic sources. However, because most non-impulse sound sources would be transient or intermittent, or both, any responses would likely be short-term behavioral responses or brief masking. Non-impulse sounds could impact individual marine invertebrates and groups of marine invertebrates close to a sound source, but they are unlikely to impact populations or subpopulations.

Corals throughout the Study Area could be exposed to non-impulse sounds generated by sonar and other acoustic sources, vessels, and aircraft during testing. There is no evidence that corals or coral larvae are sensitive to distant non-impulse sounds, although larvae may sense particle motion from close sounds. Sound from testing activities would be intermittent or transient, or both, and would not commonly occur close enough to reefs to interfere with larval perception of reef noise. Non-intermittent noise from testing activities (e.g., vessel noise) could mask reef noise. If this noise source overlapped with the larval settlement period, recruitment of larvae onto a reef habitat may be altered.

Pursuant to the ESA, sonar and other active acoustic sources associated with testing activities as described under Alternative 2 may affect ESA-listed coral species.

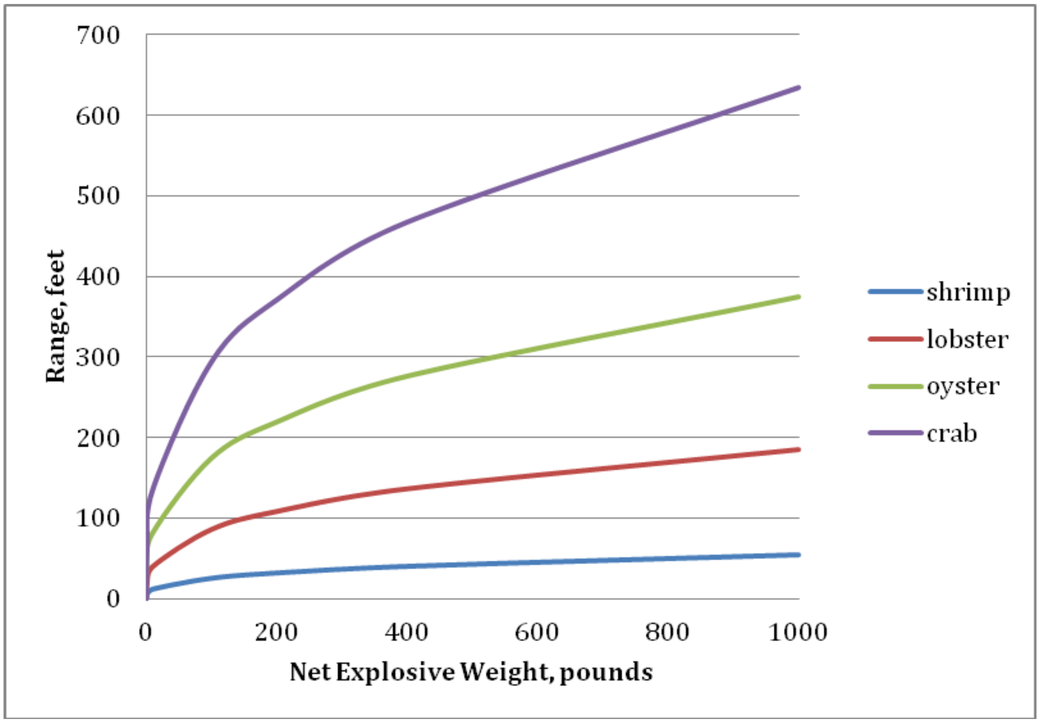
3.8.3.1.1.4 Substressor Impact on Sedentary Invertebrate Beds and Reefs as Essential Fish Habitat (Preferred Alternative)

Pursuant to the EFH requirements of the Magnuson-Stevens Fishery Conservation and Management Act and implementing regulations, the use of sonar and other active acoustic sources during training and testing activities will have no adverse effect on sedentary invertebrate beds or reefs that constitute EFH or Habitat Areas of Particular Concern within the Study Area.

3.8.3.1.2 Impacts from Explosives and Other Impulsive Sources

Explosives, weapons firing, launch, and subsequent impact of ordnance on the water's surface, and swimmer defense airguns introduce loud, impulse, broadband sounds into the marine environment. Impulse sources are characterized by rapid pressure rise times and high peak pressures. Explosions produce high-pressure shock waves that could cause injury or physical disturbance due to rapid pressure changes. Some other impulse sources, such as swimmer defense airguns, also produce shock waves, but of lower intensity. Impulse sounds are usually brief, but the associated rapid pressure changes can injure or startle marine invertebrates.

The few studies of marine invertebrates (crustaceans and molluscs) exposed to explosions show a range of impacts, from mortality close to the source to no observable effects. Limited studies of crustaceans have examined mortality rates at various distances from detonations in shallow water (Chesapeake Biological Laboratory 1948; Gaspin et al. 1976). Similar studies of molluscs have shown them to be more resistant than crustaceans to explosive impacts (Chesapeake Biological Laboratory 1948; Gaspin et al. 1976). Other invertebrates found in association with molluscs, such as sea anemones, polychaete worms, isopods, and amphipods, were observed to be undamaged in areas near detonations (Gaspin et al. 1976). Using data from these experiments, Young (1991) developed curves that estimate the distance from an explosion beyond which at least 90 percent of certain marine invertebrates would survive, depending on the weight of the explosive (Figure 3.8-7). For example, 90 percent of crabs would survive a 200-pound explosion if they are greater than 350 ft. away from the source.



Source: Young 1991

Figure 3.8-7: Prediction of Distance to 90 Percent Survivability of Marine Invertebrates Exposed to an Underwater Explosion

In deeper waters (most detonations would occur near the water surface), most benthic marine invertebrates would be beyond the 90 percent survivability ranges shown above, even for larger quantities of explosives. Some charges detonated in shallow water or near the seafloor could kill and injure marine invertebrates on or near the seafloor depending on the species and the distance to the underwater explosion. A blast in the vicinity of hard corals could cause direct impact to coral polyps or early life-stages of pre-settlement corals, or fragmentation and siltation of the corals; in one study, recovery from a single small blast directly on a reef took 5 to 10 years (Fox and Caldwell 2006). A blast near the bottom could also disturb hard substrate suitable for colonization.

Marine invertebrate mortalities and direct traumas caused by underwater and surface explosions are more likely to occur in the water column than on the bottom in deeper waters because most detonations would occur at or near the water surface. The number of organisms affected would depend on the size of the explosive, the distance from the explosion, the exact geographic location in the Study Area, and the presence invertebrates. In addition to trauma caused by a shock wave, organisms could be killed in an area of cavitation that forms near the surface above a large underwater detonation. Cavitation is where the reflected shock wave creates a region of negative pressure followed by a collapse, or water hammer.

Airguns have slower rise times and lower peak pressures than many explosives. Studies of airgun impacts on marine invertebrates have used seismic airguns, which are more powerful than any swimmer defense airguns proposed for use during Navy testing. Studies of crustaceans have shown that adult crustaceans were not noticeably physically affected by exposures to intense seismic airgun use (Christian et al. 2003; Payne et al. 2007). Snow crab eggs repeatedly exposed to airgun firings had slightly increased mortality and apparent delayed development (Christian et al. 2003), but Dungeness crab (*Metacarcinus magister*) zoeae were not affected by repeated exposures (Pearson et al. 1993). Some squid showed strong startle responses, including inking, when exposed to the first shot of broadband sound from a nearby seismic airgun (sound exposure level of 163 dB re 1 μPa^2-s), but strong startle responses were not seen when sounds were gradually increased (McCauley et al. 2000a, b). Airguns used during testing of swimmer defense systems are intended to be nonlethal swimmer deterrents, and are substantially less powerful than those used in seismic studies. It is unlikely that they would injure marine invertebrates as the swimmer defense airguns would be used only in Navy ports (Inner Apra Harbor), which does not support large marine invertebrate communities and as such, are not carried forward in the analysis.

Firing weapons on a ship generates sound from firing the gun (muzzle blast), from the shell flying through the air, and from the blast vibrating through the ship's hull. A blast wave from a gun fired above the surface of the water propagates away from the gun muzzle into the water. In addition, larger non-explosive munitions and targets could produce loud impulsive noise when hitting the water, depending on the size, weight, and speed of the object at impact. Small- and medium-caliber munitions are not expected to produce substantial impact noise.

Based on studies with airguns, some marine invertebrates exposed to impulsive sounds from swimmer defense airguns and weapons firing may exhibit startle reactions, such as inking by a squid or changes in swim speed. Similarly, marine invertebrates beyond the range to any injurious effects from exposure to explosions may also exhibit startle reactions. Repetitive impulses during multiple explosions, such as during a firing exercise, may be more likely to have injurious effects or cause avoidance reactions. However, impulsive sounds produced in water during testing and training are single impulses or multiple impulses over a limited duration (e.g., gun firing or driving a pile). Any auditory masking, in which the sound of an impulse could prevent detection of other biologically relevant sounds, would be very brief.

At a distance, impulses lose their high pressure peak and take on characteristics of non-impulsive acoustic waves. Similar to the impacts expected for non-impulsive sounds discussed previously, it is expected these exposures would cause no more than brief startle reactions in some marine invertebrates.

3.8.3.1.2.1 No Action Alternative

Training Activities

Under the No Action Alternative, marine invertebrates would be exposed to explosions and underwater impulse sounds from weapons firing, launch, and non-explosive impacts during training activities. Weapons firing, launch, and non-explosive impacts would be spread throughout the Study Area; explosions would occur during naval gunnery, missile exercises, bombing exercises, sinking exercises, tracking exercises, and mine warfare. The largest source class used during training under the No Action Alternative would be E12 (650 to 1,000 pounds [lb.] net explosive weight [NEW] [295 to 454 kilograms {kg} NEW]) (Table 3.0-9). However, of all explosives used for training under the No Action Alternative (1,594), only four are in this source class, and this source class is only used in the Study Area at distances greater than 50 nm from shore. Other than explosives used at the bombing range on FDM and discrete underwater detonation sites (e.g., in Apra Harbor) in nearshore areas (see Chapter 2, Description of Proposed Action and Alternatives), the vast majority of all explosives used under the No Action Alternative (approximately 84 percent) occur in offshore areas greater than 3 nm from shore.

Under the No Action Alternative, training activities using explosions that could occur anywhere in the Study Area, including within the Mariana littoral zones (nearshore shallow areas below the high tide line), are restricted to 50 detonations annually, all of them less than at or below the E5 source class (5–10 lb. [2.3–4.5 kg] NEW). Based on Young (1991), some charges detonated in shallow water or near the seafloor associated with mine neutralization activities could kill and injure marine invertebrates on or near the seafloor in the immediate vicinity of the detonation, though due to the low source class used, the zone of potential impact would be quite small. A blast in the vicinity of hard corals could cause fragmentation and siltation of the corals; in one study, recovery from a single small blast directly on a reef took 5 to 10 years (Fox and Caldwell 2006). It is reasonable to assume a proportion of eggs, sperm, early embryonic stages, and planula larvae of corals subjected to explosive shock and pressure waves will be deformed, die, or experience a decreased likelihood of fertilization. Mortality and lack of successful fertilization in broadcast spawning organisms are not rare, and a majority of the reproductive effort in corals fails naturally. While explosives will likely result in death of developmental stages of ESA-listed coral species, they likely have little impact on their reproductive output at the population level. A blast near the bottom could also disturb hard substrate suitable for colonization. However, as described in Section 3.3 (Marine Habitats), coral reefs and associated higher productivity areas do not overlap with the mine neutralization areas. It is not expected that a large number of pelagic invertebrates would be present in the area of these activities.

In general, explosive activities would consist of a single explosion or a few smaller explosions over a short period. Some marine invertebrates close to a detonation would likely be killed or injured. Weapons firing, launch, and non-explosive impacts would consist of a single pulse or several impulses over a short period. In general, marine invertebrates are unlikely to respond to sounds from detonations or weapons firing, launch, or impact noise unless they are very close to the sound source. Some marine invertebrates may be sensitive to the low-frequency component of impulse sound, and they may exhibit startle reactions or temporary changes in swim speed. Because the exposures are brief, limited in number, and spread over a large area, no long-term impacts are expected. Explosives and impulse sounds may impact individual marine invertebrates and groups of marine invertebrates, but they are unlikely to impact populations or subpopulations.

The vast majority of all explosives used under the No Action Alternative occur in offshore areas greater than 3 nm from shore, which are not known to support ESA-listed coral species. Additionally, air-to-ground explosives are only used at FDM. Although the island is the target, there are known instances where explosive ordnance has missed the island, falling into nearshore waters. If corals are present in areas overlapping with training activities using explosives, sessile (planula larvae that have settled out of the water column and have metamorphosed into coral polyps) shallow-water, hardbottom, and deep-water corals, as well as eggs, sperm, early embryonic stages, and planula larvae of corals could be impacted by explosions. Explosive impacts on the benthic invertebrates are more likely when an explosive is large compared to the water depth or when an explosive is detonated at or near the bottom and would include fragmentation and/or siltation. Consequences of exposure to an explosive shock wave could include breakage, injury, or mortality. Many corals and hardbottom invertebrates are sessile, fragile, and particularly vulnerable. Many of these organisms grow slowly, and could require decades to recover (Precht et al. 2001). Because most detonations occur in deeper waters near the water surface, most corals and other benthic invertebrates would not experience intense shock wave impacts.

The large number of possible explosions could alter the benthic community as mortality on hard corals could be substantial, and with continued exercises there would be no time for recovery. This would have impacts at sites where explosions are conducted in nearshore areas. Training activities that include bottom-laid underwater explosions are infrequent (only about 50 explosions per year). As presented in Chapter 3.3 (Marine Habitats), detonations on the seafloor would result in a maximum of approximately 11,500 $ft.^2$ (1,050 m^2) of disturbed substrate per year in the Study Area (Table 3.3-4), which represents less than 1 percent of the total Study Area. Additionally, detonations occur in the same area, Agat Bay Mine Neutralization Site and Outer Apra Harbor Underwater Detonation (UNDET) sites, which are located in waters that previously disturbed and are not known to support large invertebrate communities, which further reduces the potential for population level impacts.

Pursuant to the ESA, the use of explosives during training activities as described under the No Action Alternative may affect ESA-listed coral species.

<u>Testing Activities</u>

Under the No Action Alternative, there are no testing activities that involve explosive detonations or other impulse sources.

3.8.3.1.2.2 Alternative 1

<u>Training Activities</u>

Under Alternative 1, the number of explosives used during training activities would rise to 10,006 per year. Similar to the No Action Alternative, marine invertebrates would be exposed to explosions and underwater impulse sounds from weapons firing, launch, and non-explosive impacts during training activities. Weapons firing, launch, and non-explosive impacts would be spread throughout the Study Area; explosions would occur during naval gunnery, missile exercise, bombing exercise, sinking exercise, tracking exercises, and mine warfare. Approximately 94 percent of the explosions would occur in areas greater than 12 nm from shore.

The total number of explosive detonations that could occur in the shallow portions of the Study Area where corals and high productivity areas exist would increase from 50 to 94. Similar to the No Action Alternative, the source class for these activities is E5 (5 to 10 lb. [2.3 to 4.5 kg] NEW) or less. The additional detonations (either E2 [> 0.26 to 0.5 lb. {> 0.12 to 0.23 kg} NEW] or E5) in all training areas (but potentially in shallow waters) would increase the disturbance of benthic invertebrates, relative to the No Action Alternative. Shallow-water, hardbottom, and deep-water corals, as well as eggs, sperm, early embryonic stages, and planula larvae of corals could be impacted by explosions. No explosions would occur in areas known to support coral species proposed for listing.

Other than explosives used at the bombing range on FDM and discrete underwater detonation sites (e.g., in Apra Harbor) in nearshore areas (see Chapter 2, Description of Proposed Action and Alternatives) the vast majority of explosives used under Alternative 1 occur in areas greater than 3 nm from shore. These areas are not known to support coral species proposed for listing. However, if sessile shallow-water, hardbottom, and deep-water corals, as well as eggs, sperm, early embryonic stages, and planula larvae of corals are present in areas overlapping with training activities using explosives, shallow-water, hardbottom, and deep-water corals could be impacted by explosions. Under Alternative

1, Agat Bay Mine Neutralization Site changes the size of underwater detonations from 10 lb. to 20 lb. NEW. The Outer Apra Harbor UNDET and Piti Point Mine Neutralization sites remain at 10 lb. NEW. Consequences of exposure to an explosive shock wave could include breakage, injury, or mortality. Many corals and hardbottom invertebrates are sessile, fragile, and particularly vulnerable. Many of these organisms grow slowly and could require decades to recover (Precht et al. 2001). If the sites of the explosions are the same for the nearshore exercises, this could over time (years) alter the benthic composition of especially sessile invertebrates (e.g., coral). Population-level impacts in the nearshore areas could be possible depending on the size of the impacted areas. Training activities that include bottom-laid underwater explosions are infrequent (only about 50 explosions per year). As presented in Chapter 3.3 (Marine Habitats), detonations on the seafloor would result in a maximum of approximately 18,300 $ft.^2$ (1,700 m^2) of disturbed substrate per year in the Study Area (Table 3.3-4), which represents less than 1 percent of the total Study Area. Additionally, underwater detonations occur in the same areas, Agat Bay Mine Neutralization Site, Piti Floating Mine Neutralization Site, and Outer Apra Harbor underwater detonation site, which are located in waters that have previously been disturbed, and are not known to support large invertebrate communities, which further reduces the potential for population level impacts.

The remaining activities conducted under Alternative 1 utilizing explosive detonations would be restricted to portions of the Study Area that are greater than 12 nm from the shore. Additionally, air-to-ground explosives are only used at FDM. Although the island is the target, there are known instances where bombs have missed the island or rolled down into the water after impact. If corals are present in areas overlapping with training activities using explosives, sessile shallow-water, hardbottom, and deep-water corals, as well as eggs, sperm, early embryonic stages, and planula larvae of corals could be impacted by explosions. Based on Young (1991), some charges could kill and injure marine invertebrates in the immediate vicinity of the detonation, though due to the low source class used, the zone of potential impact would be quite small. Given the large area where training activities occur, and the lack of shallow water habitat greater than 2 nm away from shorelines, explosives and impulse sounds may impact individual marine invertebrates and groups of marine invertebrates, but they are unlikely to impact populations or subpopulations.

Pursuant to the ESA, the use of explosives during training activities as described under Alternative 1 may affect ESA-listed coral species.

Testing Activities

Alternative 1 would introduce testing activities that would involve the use of 6,805 high-explosives. As presented in Tables 2.8-2 through Table 2.8-4, these testing activities occur in waters greater than 3 nm from shore within the MIRC, which are not known to support ESA-listed coral species. However, if corals are present in areas overlapping with testing activities using explosives, sessile shallow-water corals, hardbottom, and deep-water corals, as well as eggs, sperm, early embryonic stages, and planula larvae of corals could be impacted by explosions. Consequences of exposure to an explosive shock wave could include breakage, injury, or mortality. Many corals and hardbottom invertebrates are sessile, fragile, and particularly vulnerable. Many of these organisms grow slowly and could require decades to recover (Precht et al. 2001).

Based on Young (1991), some explosives could kill or injure marine invertebrates in the immediate vicinity of the detonation. Some marine invertebrates may be sensitive to the low-frequency component of impulse sound, and they may exhibit startle reactions or temporary changes in swim speed. However, because the exposures are brief, limited in number, and spread over a large area, no long-term impacts are expected. Explosives may impact individual marine invertebrates and groups of marine invertebrates, but they are unlikely to impact populations or subpopulations. Other less intense impulsive sounds (e.g., swimmer defense airguns) are not expected to affect marine invertebrates as discussed in Section 3.8.3.1.2 (Impacts from Explosives and Other Impulsive Sources).

Pursuant to the ESA, the use of explosives during testing activities as described under Alternative 1 may affect ESA-listed coral species.

3.8.3.1.2.3 Alternative 2

Training Activities

Under Alternative 2, the number of explosives used during training activities would rise from 1,594 to 10,284 per year, as compared to the No Action Alternative. Similar to the No Action Alternative, marine invertebrates would be exposed to explosions and underwater impulse sounds from weapons firing, launch, and non-explosive impacts during training activities. Weapons firing, launch, and non-explosive impacts would be spread throughout the Study Area; explosions would occur during naval gunnery, missile exercises, bombing exercises, sinking exercises, tracking exercises, and mine warfare.

The vast majority (approximately 94 percent) of all explosives used under Alternative 2 occur in areas greater than 3 nm from shore, which are not known to support listed coral species. Additionally, air-to-ground explosives are only used at FDM. Although the island is the target, there are known instances where bombs have missed the island or rolled down into the water after impact. If corals are present in areas overlapping with training activities using explosives, sessile shallow-water corals, hardbottom, and deep-water corals, as well as eggs, sperm, early embryonic stages, and planula larvae of corals could be impacted by explosions. Under Alternative 2, Agat Bay Mine Neutralization Site changes the size of underwater detonations from 10 lb. to 20 lb. NEW. The Outer Apra Harbor UNDET and Piti Point Mine Neutralization sites remain at 10 lb. NEW. Consequences of exposure to an explosive shock wave could include breakage, injury, or mortality.

The total number of explosive detonations that could occur in the shallow portions of the Study Area where corals and high productivity areas exist would increase. Similar to the No Action Alternative, the source class for these activities is E5 (5 to 10 lb. [2.3 to 4.5 kg] NEW) or less. The additional detonations (either E2 [> 0.26 to 0.5 lb. {> 0.12 to 0.23 kg} NEW] or E5) in all training areas (but potentially in shallow waters) would increase the disturbance of benthic invertebrates, relative to the No Action Alternative.

If an ESA-listed coral species of any life stage (or any other coral species) were to occur in areas used during training activities, consequences of exposure to an explosive shock wave could include breakage, injury, or mortality. Many corals and hardbottom invertebrates are sessile, fragile, and particularly vulnerable. Many of these organisms grow slowly and could require decades to recover (Precht et al. 2001). If the sites of the explosions are the same for the nearshore exercises, this could over time (years) alter the benthic composition of especially sessile invertebrates (e.g., coral). Population-level impacts in the nearshore areas could be possible depending on the size of the impacted areas. However, training activities that include bottom-laid underwater explosions are infrequent (only about 50 explosions per year), and the percentage of training area affected is small (less than 1 percent of the total Study Area). Additionally, detonations occur in the same area, Agat Bay Mine Neutralization Site and Outer Apra Harbor UNDET sites, which are located in waters that are previously disturbed and not known to support large invertebrate communities, which further reduces the potential for population level impacts. It is reasonable to assume a proportion of eggs, sperm, early embryonic stages, and planula larvae of ESA-listed corals subjected to explosive shock and pressure waves will be deformed, die, or experience a decreased likelihood of fertilization. Mortality and lack of successful fertilization in broadcast spawning organisms are not rare, and a majority of the reproductive effort in ESA-listed coral species likely fails naturally. While explosives will likely result in death of developmental stages of ESA-listed coral species, they likely have little impact on their reproductive output at the population level.

The remaining activities conducted under Alternative 2 utilizing explosive detonations would be restricted to portions of the Study Area that are greater than 12 nm from the shore. Over 9,710 detonations could occur, and 98 percent of these detonations would be restricted to source class E6 (> 10 to 20 lb. [> 4.5 to 9.1 kg] NEW) or less (Table 3.0-9). Based on Young (1991), some charges could kill and injure marine invertebrates in the immediate vicinity of the detonation, though due to the low source class used, the zone of potential impact would be quite small. Given the large area where training activities occur, and the lack of shallow water habitat greater than 2 nm away from shorelines, explosives and impulse sounds may impact individual marine invertebrates and groups of marine invertebrates (including pelagic larvae).

Pursuant to the ESA, the use of explosives during training activities as described under Alternative 1 may affect ESA-listed coral species.

Testing Activities

Alternative 2 would introduce testing activities that would involve the use of 8,335 high-explosives, all of which could occur throughout the Study Area, although the majority occur in waters greater than 3 nm from shore within the MIRC. Because these detonations occur in deeper waters near the water surface, most corals and other benthic invertebrates would not experience intense shock wave impacts. If an ESA-listed coral species of any life stage (or any other coral species) were to occur in areas used during testing activities, consequences of exposure to an explosive shock wave could include breakage, injury, or mortality. Many corals and hardbottom invertebrates are sessile, fragile, and particularly vulnerable. Many of these organisms grow slowly, and could require decades to recover (Precht et al. 2001).

Based on Young (1991), some explosive charges could kill and injure marine invertebrates in the immediate vicinity of the detonation. Some marine invertebrates may be sensitive to the low-frequency component of impulse sound, and they may exhibit startle reactions or temporary changes in swim speed. However, because the exposures are brief, limited in number, and spread over a large area, no long-term impacts are expected. Explosives and impulsive sounds may impact individual marine invertebrates and groups of marine invertebrates, but they are unlikely to impact populations or subpopulations. Other less intense impulsive sounds (e.g., swimmer defense airguns) are not expected to affect marine invertebrates as discussed in Section 3.8.3.1.2 (Impacts from Explosives and Other Impulsive Sources).

Pursuant to the ESA, the use of explosives during training activities as described under Alternative 1 may affect ESA-listed coral species.

3.8.3.1.2.4 Substressor Impact on Sedentary Invertebrate Beds and Reefs as Essential Fish Habitat (Preferred Alternative)

Pursuant to the EFH requirements of the Magnuson-Stevens Fishery Conservation and Management Act and implementing regulations, the use of explosives and other impulsive sources during training and testing activities may have an adverse effect on EFH by reducing the quality or quantity of sedentary invertebrate beds or reefs that constitute EFH or Habitat Areas of Particular Concern. The use of other impulsive sources (swimmer defense airguns; and weapons firing, launch, and impact noise) during training and testing activities will not have an adverse effect on EFH by reducing the quality or quantity of sedentary invertebrate beds or offshore reefs that constitute EFH or Habitat Areas of Particular Concern within the Study Area.

3.8.3.1.3 Summary of Impacts from Acoustic Stressors

Most testing and training activities would generate underwater impulse or non-impulse sounds from some combination of several sources, including sonar, other active acoustic sources, vessels, aircraft, explosions, airguns, weapons firing, weapons launches, or non-explosive impacts. Both pelagic and benthic marine invertebrates could be impacted by these stressors. In most cases, marine invertebrates would not respond to impulse and non-impulse sounds, although they may detect and briefly respond to nearby low-frequency sounds. These short-term responses would likely be inconsequential. Explosions would likely kill or injure nearby marine invertebrates. Explosions near the seafloor and very large explosions in the water column may impact shallow water corals of any life stage, hardbottom habitat and associated marine invertebrates, and deep-water corals, including physical disturbance, fragmentation, or mortality (both to sessile organisms and pelagic larvae). Most explosions at the water surface would not injure benthic marine invertebrates because the explosive weights would be small compared to the water depth. Additionally, the vast majority of explosions occur at distances greater than 3 nm from shore, in water depths greater than those for shallow water coral species.

3.8.3.2 Energy Stressors

This section analyzes the potential impacts of the various types of energy stressors that can occur during training and testing activities within the Study Area. This section includes analysis of the potential impacts from electromagnetic devices.

3.8.3.2.1 Impacts from Electromagnetic Devices

Several different types of electromagnetic devices are used during training and testing activities. For a discussion of the types of activities that use electromagnetic devices, where they are used, and how many activities would occur under each alternative, please see Section 3.0.5.2.2.1 (Electromagnetic Devices). Aspects of electromagnetic stressors that are applicable to marine organisms in general are presented in Appendix H, Section H.3 (Conceptual Framework for Assessing Effects from Energy-Producing Activities).

Little information exists about marine invertebrates' susceptibility to electromagnetic fields. Most corals are thought to use water temperature, day length, lunar cycles, and tidal fluctuations as cues for spawning. Magnetic fields are not known to control coral spawning release or larval settlement. Some arthropods (e.g., spiny lobster and American lobster) can sense magnetic fields, and this ability is thought to assist the animal with navigation and orientation (Lohmann et al. 1995; Normandeau et al. 2011). These animals travel relatively long distances during their lives, and magnetic field sensation may exist in other invertebrates that travel long distances. Marine invertebrates, including several commercially important species and federally managed species, could use magnetic cues (Normandeau et al. 2011). Susceptibility experiments have focused on arthropods, but several mollusks and echinoderms are also susceptible. However, because susceptibility is variable within taxonomic groups it is not possible to make generalized predictions for groups of marine invertebrates. Sensitivity thresholds vary by species ranging from 0.3 to 30 milliteslas, and responses included non-lethal physiological and behavioral changes (Normandeau et al. 2011). The primary use of magnetic cues seems to be navigation and orientation. Human-introduced electromagnetic fields could disrupt these cues and interfere with navigation, orientation, or migration. Because electromagnetic fields weaken exponentially with increasing distance from their source, large and sustained magnetic fields present greater exposure risks than small and transient fields, even if the small field is many times stronger than the earth's magnetic field (Normandeau et al. 2011). Transient or moving electromagnetic fields may cause temporary disturbance to susceptible organisms' navigation and orientation.

3.8.3.2.1.1 No Action Alternative

Training Activities

Under the No Action Alternative, there are no training activities that involve the use of electromagnetic devices.

Testing Activities

Under the No Action Alternative, there are no testing activities that involve the use of electromagnetic devices.

3.8.3.2.1.2 Alternative 1

Training Activities

As indicated in Section 3.0.5.2.2.1 (Electromagnetic Devices), training activities involving electromagnetic devices under Alternative 1 occur up to five times annually as part of MCM (towed mine detection) and Civilian Port Defense activities. Table 2.8-1 lists the number and location of training activities that use electromagnetic devices. Little information exists about marine invertebrates' susceptibility to electromagnetic fields. Most corals are thought to use water temperature, day length, lunar cycles, and tidal fluctuations as cues for spawning. Magnetic fields are not known to influence coral spawning or larval settlement.

The impact of electromagnetic fields on marine invertebrates, including ESA-listed coral species, would be inconsequential because: (1) the area exposed to the stressor is extremely small relative to most marine invertebrates' ranges; (2) the number of activities involving the stressor is low; (3) exposures would be localized, temporary, and would cease with the conclusion of the activity; and (4) even for invertebrates that may be susceptible (e.g., some species of arthropods, mollusks, and echinoderms) the consequences of exposure would be limited to temporary disruptions to navigation and orientation.

Pursuant to the ESA, the use of electromagnetic devices during training activities as described under Alternative 1 would have no effect on ESA-listed coral species.

Testing Activities

Mine countermeasure mission package testing includes the use of electromagnetic devices that generate electromagnetic fields underwater to detect mines. Under Alternative 1, the Naval Sea Systems Command will engage in up to 32 MCM mission package testing activities annually.

The impact of electromagnetic fields on marine invertebrates, including ESA-listed coral species, would be inconsequential because: (1) the area exposed to the stressor is extremely small relative to most marine invertebrates' ranges; (2) the number of activities involving the stressor is low; (3) exposures would be localized, temporary, and would cease with the conclusion of the activity; and (4) even for invertebrates that may be susceptible (e.g., some species of arthropods, mollusks, and echinoderms) the consequences of exposure are limited to temporary disruptions to navigation and orientation.

Pursuant to the ESA, the use of electromagnetic devices during testing activities as described under Alternative 1 would have no effect on ESA-listed coral species.

3.8.3.2.1.3 Alternative 2

Training Activities

As indicated in Section 3.0.5.2.2.1 (Electromagnetic Devices), training activities involving electromagnetic devices under Alternative 2 occur up to five times annually as part of MCM (towed mine detection) and Civilian Port Defense activities. Table 2.8-1 lists the number and location of training activities that use electromagnetic devices.

The impact of electromagnetic fields on marine invertebrates would be inconsequential because: (1) the area exposed to the stressor is extremely small relative to most marine invertebrates' ranges; (2) the number of activities involving the stressor is low; (3) exposures would be localized, temporary, and would cease with the conclusion of the activity; and (4) even for susceptible organisms invertebrates (e.g., some species of arthropods, mollusks, and echinoderms) the consequences of exposure are limited to temporary disruptions to navigation and orientation.

Pursuant to the ESA, the use of electromagnetic devices during training activities as described under Alternative 2 would have no effect on ESA-listed coral species.

Testing Activities

Mine countermeasure mission package testing includes the use of electromagnetic devices that generate electromagnetic fields underwater to detect mines. Under Alternative 2, the Naval Sea Systems Command will engage in up to 36 MCM mission package testing activities annually.

The impact of electromagnetic fields on marine invertebrates, including ESA-listed coral species, would be inconsequential because: (1) the area exposed to the stressor is extremely small relative to most marine invertebrates' ranges; (2) the number of activities involving the stressor is low; (3) exposures would be localized, temporary, and would cease with the conclusion of the activity; and (4) even for susceptible organisms invertebrates (e.g., some species of arthropods, mollusks, and echinoderms) the consequences of exposure are limited to temporary disruptions to navigation and orientation.

Pursuant to the ESA, the use of electromagnetic devices during testing activities as described under Alternative 2 would have no effect on ESA-listed coral species.

3.8.3.2.1.4 Substressor Impacts on Sedentary Invertebrate Beds or Reefs as Essential Fish Habitat

Pursuant to the EFH requirements of the Magnuson-Stevens Fishery Conservation and Management Act and implementing regulations, the use of electromagnetic devices during training and testing activities will have minimal and temporary adverse effects on invertebrates that occupy water column EFH or Habitat Areas of Particular Concern, and will have no adverse effect on sedentary invertebrate beds or reefs that constitute EFH or Habitat Areas of Particular Concern within the Study Area.

3.8.3.3 Physical Disturbance and Strike Stressors

This section analyzes the potential impacts of the various types of physical disturbance and strike stressors caused by Navy training and testing activities within the Study Area. For a list of locations and numbers of activities that may cause physical disturbance and strikes refer to Section 3.3.3.2 (Physical Disturbance and Strike Stressors) as well as Appendix A for details regarding Amphibious Assaults/Amphibious Raids. The physical disturbance and strike stressors that may impact marine invertebrates include (1) vessels and in-water devices, (2) military expended materials, and (3) seafloor devices.

Most marine invertebrate populations extend across wide areas containing hundreds or thousands of discrete patches of suitable habitat. Sessile (attached to the seafloor or other surface) invertebrate populations may be maintained by complex currents that carry adults and young from place to place. Such widespread populations are difficult to evaluate in terms of Navy training and testing activities that occur intermittently and in relatively small patches in the Study Area. Even invertebrate populations that are somewhat restricted in range, such as coral reefs, cover enormous areas (see Section 3.3, Marine Habitats, for quantitative assessments). In this context, a physical strike or disturbance would impact individual organisms directly or indirectly.

With few exceptions, activities involving vessels and in-water devices are not intended to contact the seafloor. Except for amphibious activities and bottom-crawling unmanned underwater vehicles, there is minimal potential strike impact and limited potential disturbance impact on benthic or habitat-forming marine invertebrates. For environmental and safety- reasons amphibious landings and other nearshore activities would avoid areas where corals are known to occur.

With the exception of corals and other sessile benthic invertebrates, most mobile invertebrate populations recover quickly from non-extractive disturbance. Other invertebrates, such as the small soft-bodied organisms that live in the bottom sediment, are thought to be well-adapted to natural physical disturbances, although recovery from human-induced disturbance is delayed by decades or more (Kaiser et al. 2002; Lindholm et al. 2011). Biogenic habitats such as coral reefs, deep coral, and sponge communities may take decades to re-grow following a strike or disturbance (Jennings and Kaiser 1998; Precht et al. 2001). If the sites of the activities are the same for repeated exercises, this could over time (years) alter the benthic composition, especially sessile invertebrates (e.g., coral).

3.8.3.3.1 Impacts from Vessels and In-Water Devices

The majority of the training and testing activities under all the alternatives involve vessels, and a few of the activities involve the use of in-water devices (such as remotely operated vehicles, unmanned surface vehicles and unmanned undersea vehicles, and towed devices). Vessels and in-water devices could impact marine invertebrates by disturbing the water column or sediments, or directly striking organisms (Bishop 2008). The propeller wash (water displaced by propellers used for propulsion) from vessel movement and water displaced from vessel hulls could disturb marine invertebrates in the water column, and is a likely cause of zooplankton mortality (Bickel et al. 2011). This local and short-term exposure to vessel and propeller movements could displace, injure, or kill zooplankton, invertebrate eggs or larvae, and macro-invertebrates in the upper portions of the water column.

Few sources of information are available on the impact of non-lethal chronic disturbance on marine invertebrates. One study of seagrass-associated marine invertebrates found that chronic disturbance from vessel wakes resulted in the long-term displacement of some marine invertebrates from the impacted shallow-water area (Bishop 2008). Impacts of this type resulting from repeated exposure in shallow water are not likely to result from Navy training and testing activities because (1) most vessel movements occur in relatively deep water, and (2) vessel movements are concentrated in well-established port facilities and associated channels (Mintz and Parker 2006).

Vessels and towed in-water devices do not normally collide with invertebrates that inhabit the seafloor because Navy vessels are operated in relatively deep waters and have navigational capabilities to avoid contact with these habitats. A consequence of vessel operation in shallow water is increased turbidity from stirring-up bottom sediments. Turbidity can impact corals and invertebrate communities on hardbottom areas by reducing the amount of light that reaches these organisms and by increasing the energy the organism expends on sediment removal (Riegl and Branch 1995). Reef-building corals are sensitive to water clarity because of their symbiotic algae (i.e., zooxanthellae) that require sunlight to live. Encrusting organisms residing on hardbottom can be impacted by persistent silting from increased turbidity. In addition, propeller wash and physical contact with coral and hardbottom areas can cause structural damage to the substrate, as well as mortality to encrusting organisms. While information on the frequency of vessel operations in shallow water is not adequate to support a specific risk assessment, typical navigational procedures minimize the likelihood of contacting the seafloor, and most Navy vessel movements in nearshore waters are confined to established channels and ports, or predictable transit lanes to adjoining training areas through deep water.

The Navy would also conduct activities that use unmanned undersea systems and unmanned surface systems. These systems can operate anywhere from the water's surface to the benthic zone. Certain devices do not have a realistic potential to strike living marine resources because they either move slowly through the water column (e.g., most unmanned undersurface vehicles) or are closely monitored by observers manning the towing platform (e.g., most towed devices). Additionally, most of the vehicles use advanced propeller systems with encased propellers to prevent damage to sea beds (seafloor fauna such as corals). Even at low speeds, however, coral larvae in the water column could be displaced, injured, or killed by unmanned underwater vehicle movements. However, the number of individual larvae exposed would be quite small in comparison to the total number of coral larvae that are produced by reproduction, and impacts to coral populations from unmanned underwater vehicles are expected to be inconsequential. Zooplankton, invertebrate eggs or larvae, and macro-invertebrates in the water column could be displaced, injured, or killed by unmanned underwater vehicle movements.

3.8.3.3.1.1 No Action Alternative

Training Activities

As indicated above, the majority of the training activities under all alternatives involve vessels, and a few of the activities involve the use of in-water devices. These activities could be widely dispersed throughout the Study Area, but would be more concentrated near naval ports, piers, and range areas. Large, slow vessels would pose little risk to marine invertebrates in the open ocean although, in coastal waters, currents from large vessels may cause resuspension and settlement of sediment onto sensitive invertebrate communities. Fast boats would generally pose more of a risk through propeller action in shallow waters. This action may affect a proportion of eggs, sperm, early embryonic stages, and planula larvae of ESA-listed coral species subjected to the shearing forces of turbulent waters from the hulls, propellers, or jets of vessels. Mortality and lack of successful fertilization in broadcast spawning organisms are not rare, and a majority of the reproductive effort of broadcast spawning organisms fails naturally. While vessel movement may affect the developmental life stages of ESA-listed coral species, it likely has little impact on their reproductive output at the population level.

Exposure of marine invertebrates to vessel disturbance and strikes would be limited to organisms in the water column, and primarily in the uppermost portions of the water column. Most pelagic marine invertebrates are disturbed as the water flows around the vessel, towed in-water device, or autonomous vehicle. Injury or mortality caused directly or indirectly by propellers is possible, but the scale of impacts would be limited, and population-level impacts are unlikely. Under the No Action Alternative, these shallow-water vessels would continue to operate in defined boat lanes with sufficient depths to avoid propeller or hull strikes of benthic invertebrates on the seafloor, thereby minimizing impacts to invertebrate populations.

Amphibious Assault and Amphibious Raids could occur up to four and two times annually, respectively. These could occur at beaches at Una Babui, Una Chulu, and Unai Dankulo on Tinian and can also occur at Dry Dock Island in Apra Harbor, Dadi Beach on Guam. Benthic invertebrates of the reef crest or flat, such as crabs, clams, and polychaete worms, within the disturbed area could be displaced, injured, or killed during amphibious operations. As is current practice, exposure of coral and other hard bottom habitats would be avoided in the No Action Alternative. Prior to any amphibious over-the-beach training activity conducted with larger amphibious vehicles such as Landing Craft Air Cushions (LCACs) or Amphibious

Assault Vehicles (AAVs) (e.g., Amphibious Assaults), a hydrographic survey and a beach survey would be required. The surveys would be conducted to identify and designate boat lanes and beach landing areas that are clear of coral, hard bottom substrate, and obstructions. LCAC landing and departure activities would be scheduled at high tide. In addition, LCACs would stay fully on cushion or hover when over shallow reef to avoid corals and hard bottom substrate. This is a standard operating procedure for safe operation of LCACs. Over-the-beach amphibious activity would only occur within designated areas based on the hydrographic and beach surveys. Similarly, AAV activities would only be scheduled within designated boat lanes and beach landing areas and would conduct their beach landings and departures at high tide one vehicle at a time within their designated boat lane (Commander, US. Naval Forces Marianas Instruction [COMNAVMARINST] 3500.4A). Based on the surveys, if the beach landing area and boat lane is clear, the activity could be conducted, and crews would follow procedures to avoid obstructions to navigation, including coral reefs; however, if there is any potential for impacts to occur on corals or hard bottom substrate, the Navy will coordinate with applicable resource agencies before conducting the activity. Hydrographic and beach surveys would not be necessary for beach landings with small boats, such as Rigid Hull Inflatable Boats (RHIBs).

Benthic invertebrates within the disturbed area, such as crabs, clams, and polychaete worms, could be displaced, injured, or killed during amphibious operations. Benthic invertebrates inhabiting these areas are adapted to a highly variable environment and are expected to rapidly re-colonize disturbed areas by immigration and larval recruitment. Studies indicate that benthic communities of high-energy sandy beaches recover relatively quickly (typically within 2 to 7 months) following beach nourishment (U.S. Army Corps of Engineers 2001). Schoeman et al. (2000) found that the macrobenthic (visible organisms on the seafloor) community required between 7 and 16 days to recover following excavation and removal of sand from a 2,153 $ft.^2$ (200 m^2) quadrant in the mid-intertidal zone of a sandy beach.

Exposure of marine invertebrates to vessel disturbance and strikes would be limited to organisms in the water column (primarily in the uppermost portions of the water column) and organisms occupying shallow water habitats. Most pelagic marine invertebrates are disturbed as the water flows around the vessel, towed in-water device, or autonomous vehicle. A consequence of vessel operation in shallow water is increased turbidity from stirring-up bottom sediments as well as the potential for running aground. Turbidity can impact corals and invertebrate communities in shallow water areas by reducing the amount of light that reaches these organisms and by increasing the effort the organism expends on sediment removal (Riegl and Branch 1995). Reef-building corals are sensitive to water clarity because of their symbiotic algae (i.e., zooxanthellae) that require sunlight to live. Encrusting organisms residing on hardbottom can be impacted by persistent silting from increased turbidity. In addition, propeller wash and physical contact with coral and hardbottom areas can cause structural damage to the substrate, as well as mortality to encrusting organisms. Injury or mortality caused directly or indirectly by propellers or vessels is possible, but the scale of impacts would be limited, and population-level impacts are unlikely.

The impact of vessels and in-water devices on marine invertebrates would be inconsequential because: (1) the area exposed to the stressor amounts to a small portion of each vessel's and in-water device's footprint, and is extremely small relative to most marine invertebrates' ranges; (2) the frequency of activities involving the stressor is low such that few individuals could be exposed to more than one event; and (3) exposures would be localized, temporary, and would cease with the conclusion of the activity. Activities involving vessels and in-water devices are not expected to yield any behavioral changes or lasting effects on the survival, growth, recruitment, or reproduction of invertebrate species at the population level.

Pursuant to the ESA, vessel or in-water device strikes or physical disturbance from training activities as described under the No Action Alternative may affect ESA-listed coral species.

Testing Activities

Under the No Action Alternative, there are no testing activities except for vessels transiting to the North Pacific Acoustic Lab Philippine Sea Experiment site. This action may affect a proportion of eggs, sperm, early embryonic stages, and planula larvae of ESA-listed coral species subjected to the shearing forces of turbulent waters from the hulls, propellers, or jets of vessels. Mortality and lack of successful fertilization in broadcast spawning organisms are not rare, and a majority of the reproductive effort of broadcast spawning organisms fails naturally. While vessel movement may affect the developmental life stages of ESA-listed corals, it likely has little impact on their reproductive output at the population level.

The impact of vessels on marine invertebrates would be inconsequential because: (1) the area exposed to the stressor amounts to a small portion of each vessel's and in-water device's footprint, and is extremely small relative to most marine invertebrates' ranges; (2) the frequency of activities involving the stressor is low such that few individuals could be exposed to more than one event; and (3) exposures would be localized, temporary, and would cease with the conclusion of the activity. Activities involving vessels and in-water devices are not expected to yield any behavioral changes or lasting effects on the survival, growth, recruitment, or reproduction of invertebrate species at the population level

Pursuant to the ESA, vessel or in-water device strikes or physical disturbance from testing activities as described under the No Action Alternative may affect ESA-listed coral species.

3.8.3.3.1.2 Alternative 1

Training Activities

As described in Section 2.7.3.2 (Ships), additional ships are proposed under Alternative 1 as well as increase in overall vessel use in the Study Area. The replacement of the Nimitz Class aircraft carriers would introduce new aircraft carriers into the activities described in this EIS/OEIS. The first replacement Gerald Ford Class aircraft carrier is expected to be operational within the MITT Study Area in 2015. The replacement of Nimitz Class aircraft carriers would not increase the potential for marine invertebrate disturbance because there would be no net increase of aircraft carriers within the Study Area, the operational differences between Nimitz and Gerald Ford Classes are minor, and no new training activities would result from the introduction of Gerald Ford Class aircraft carriers.

Under Alternative 1, the Navy plans to introduce a new class of destroyers (Zumwalt Class, Multi-Mission Destroyers), which would require increased training exercises relative to existing destroyer class ships. Although the increase in training would increase the potential for disturbance of marine invertebrates, the impacts of the Zumwalt Class destroyers during training and testing activities would not differ from those of existing destroyers. Therefore, the likelihood of disturbance would increase not because of the new destroyer class, but because of increased vessel movements under Alternative 1. However, as described above, vessels do not normally collide with invertebrates because Navy vessels are operated in relatively deep waters and also have navigational capabilities to avoid contact with benthic habitats.

Alternative 1 also proposes to introduce new vessels (not replacement class vessel for existing vessels). The Littoral Combat Ship, the Joint High Speed Vessel, and the Expeditionary Fighting Vehicle are all fast vessels that may operate in nearshore waters. These areas typically support marine invertebrates within the water column and benthic habitats, so the potential for disturbance or strike of marine invertebrates in nearshore waters would increase.

In addition to manned ships, the Navy also proposes to introduce unmanned undersea and surface systems under Alternative 1. These devices can operate anywhere from the water surface to the benthic zone. Certain devices do not have a realistic potential to strike living marine resources because they either move slowly through the water column (e.g., most unmanned undersurface vehicles) or are closely monitored by observers manning the towing platform (e.g., most towed devices). Even at low speeds, however, zooplankton, invertebrate eggs or larvae, corals, and macro-invertebrates in the water column could be displaced, injured, or killed by unmanned underwater vehicle movements. Consequences of exposure of corals to an unmanned undersea and surface system could include breakage, injury, or mortality. As described above, while vessels may affect the developmental stages of ESA-listed coral species, they likely have little impact on their reproductive output at the population level.

Because of their size and potential operating speed, in-water devices that operate in a manner with the potential to strike living marine resources are the Unmanned Surface Vehicles. All of the vehicles described in Section 2.7.3.3 (Unmanned Vehicles and Systems) use advanced propeller systems with encased propellers to prevent damage to sea beds (seafloor fauna, such as corals and other invertebrate species). The Sea Maverick Unmanned Surface System operates in harbors and bays; therefore, it could increase the risk of interactions with marine invertebrates. A consequence of vessel operation in shallow water is increased turbidity from stirring-up bottom sediments. Bottom sediments would be disturbed, and localized increases in turbidity would occur when an in-water device makes contact with the seafloor, but turbidity would quickly dissipate (i.e., time scales of minutes to hours) following the exercise. Training activities that involve the use of unmanned surface or underwater activities include Amphibious Raid activities (Table 2.8-1), which occur six times a year.

Amphibious Assault and Amphibious Raids could occur up to six times each annually. These could occur at beaches at Una Babui, Una Chulu, and Unai Dankulo on Tinian and can also occur at Dry Dock Island in Apra Harbor, Dadi Beach on Guam. Benthic invertebrates of the reef crest or flat, such as crabs, clams, and polychaete worms, within the disturbed area could be displaced, injured, or killed during amphibious operations. As is current practice, exposure of coral and other hard bottom habitats would continue to be avoided in the Proposed Action.

Prior to any amphibious over-the-beach training activity conducted with larger amphibious vehicles such as LCACs or AAVs (e.g., Amphibious Assaults), a hydrographic survey and a beach survey would be required. The surveys would be conducted to identify and designate boat lanes and beach landing areas that are clear of coral, hard bottom substrate, and obstructions. LCAC landing and departure activities would be scheduled at high tide. In addition, LCACs would stay fully on cushion or hover when over shallow reef to avoid corals and hard bottom substrate. This is a standard operating procedure for safe operation of LCACs. Over-the-beach amphibious activity would only occur within designated areas based on the hydrographic and beach surveys. Similarly, AAV activities would only be scheduled within designated boat lanes and beach landing areas and would conduct their beach landings and departures at high tide one vehicle at a time within their designated boat lane (COMNAVMARINST 3500.4A). Based on the surveys, if the beach landing area and boat lane is clear, the activity could be conducted, and crews would follow procedures to avoid obstructions to navigation, including coral reefs; however, if there is any potential for impacts to occur on corals or hard bottom substrate, the Navy will coordinate with applicable resource agencies before conducting the activity. Hydrographic and beach surveys would not be necessary for beach landings with small boats, such as RHIBs.

Benthic invertebrates within the disturbed area, such as crabs, clams, and polychaete worms, could be displaced, injured, or killed during amphibious operations. Benthic invertebrates inhabiting these areas are adapted to a highly variable environment and are expected to rapidly re-colonize disturbed areas by immigration and larval recruitment. Studies indicate that benthic communities of high-energy sandy beaches recover relatively quickly (typically within 2 to 7 months) following beach nourishment (U.S. Army Corps of Engineers 2001). Schoeman et al. (2000) found that the macrobenthic (visible organisms on the seafloor) community required between 7 and 16 days to recover following excavation and removal of sand from a 2,153 $ft.^2$ (200 m^2) quadrant in the mid-intertidal zone of a sandy beach.

Exposure of marine invertebrates to vessel disturbance and strikes would be limited to organisms in the water column (primarily in the uppermost portions of the water column) and organisms occupying shallow water habitats. Species that do not occur near the surface within the Study Area—including ESA-listed coral species—would not be exposed to vessel strikes. Most pelagic marine invertebrates are disturbed as the water flows around the vessel, towed in-water device, or autonomous vehicle. A consequence of vessel operation in shallow water is increased turbidity from stirring-up bottom sediments as well as the potential for running aground. Turbidity can impact corals and invertebrate communities in shallow water areas by reducing the amount of light that reaches these organisms and by increasing the effort the organism expends on sediment removal (Riegl and Branch 1995). Reef-building corals are sensitive to water clarity because of their symbiotic algae (i.e., zooxanthellae) that require sunlight to live. Encrusting organisms residing on hardbottom can be impacted by persistent silting from increased turbidity. In addition, propeller wash and physical contact with coral and hardbottom areas can cause structural damage to the substrate, as well as mortality to encrusting organisms. Injury or mortality caused directly or indirectly by propellers or vessels is possible, but the scale of impacts would be limited, and population-level impacts are unlikely.

The impact of vessels and in-water devices on marine invertebrates would be inconsequential because: (1) the area exposed to the stressor amounts to a small portion of each vessel's and in-water device's footprint, and is extremely small relative to most marine invertebrates' ranges; (2) the frequency of activities involving the stressor is low such that few individuals could be exposed to more than one event; and (3) exposures would be localized, temporary, and would cease with the conclusion of the activity. Activities involving vessels and in-water devices are not expected to yield any behavioral changes or lasting effects on the survival, growth, recruitment, or reproduction of invertebrate species at the population level.

Pursuant to the ESA, vessel or in-water device strikes or physical disturbance from training activities as described under Alternative 1 may affect ESA-listed coral species.

Testing Activities

Alternative 1 would introduce new testing activities into the Study Area involving ships and underwater vehicle types. Exposure of marine invertebrates to vessel disturbance and strikes would be limited to organisms in the water column, and primarily in the uppermost portions of the water column. Species that do not occur near the surface within the Study Area—including sessile ESA-listed coral species—would not be exposed to vessel strikes. The number of individual larvae exposed would be quite small in comparison to the total number of coral larvae that are produced by reproduction, and impacts to coral populations from unmanned underwater vehicles are expected to be inconsequential.

Most pelagic marine invertebrates are disturbed as the water flows around the vessel, towed in-water device, or autonomous vehicle. Injury or mortality caused directly or indirectly by propellers is possible, but the scale of impacts would be limited, and population-level impacts are unlikely.

The impact of vessels and in-water devices on marine invertebrates would be inconsequential because: (1) the area exposed to the stressor amounts to a small portion of each vessel's and in-water device's footprint, and is extremely small relative to most marine invertebrates' ranges; (2) the frequency of activities involving the stressor is low such that few individuals could be exposed to more than one event; and (3) exposures would be localized, temporary, and would cease with the conclusion of the activity. Activities involving vessels and in-water devices are not expected to yield any behavioral changes or lasting effects on the survival, growth, recruitment, or reproduction of invertebrate species at the population level.

Pursuant to the ESA, vessel or in-water device strikes or physical disturbance from testing activities as described under Alternative 1 may affect ESA-listed coral species.

3.8.3.3.1.3 Alternative 2

Training Activities

As described for Alternative 1, Alternative 2 includes the same new ship classes and vessels and activity numbers. Exposure of marine invertebrates to vessel disturbance and strikes would be limited to organisms in the water column (primarily in the uppermost portions of the water column) and organisms occupying shallow water habitats. As described above, while vessels may affect the developmental stages of ESA-listed coral species in the water column, they likely have little impact on their reproductive output at the population level. Species that do not occur near the surface within the Study Area—including ESA-listed coral species—would not be exposed to vessel strikes. Injury or mortality caused directly or indirectly by propellers or vessels is possible, but the scale of impacts would be limited, and population-level impacts are unlikely.

Amphibious Assault and Amphibious Raids could occur up to six times each annually. These could occur at beaches at Una Babui, Una Chulu, and Unai Dankulo on Tinian and can also occur at Dry Dock Island in Apra Harbor, Dadi Beach on Guam. Benthic invertebrates of the reef crest or flat, such as crabs, clams, and polychaete worms, within the disturbed area could be displaced, injured, or killed during amphibious operations. As is current practice, exposure of coral and other hard bottom habitats would continue to be avoided in the Proposed Action.

Prior to any amphibious over-the-beach training activity conducted with larger amphibious vehicles such as LCACs or AAVs (e.g., Amphibious Assaults), a hydrographic survey and a beach survey would be required. The surveys would be conducted to identify and designate boat lanes and beach landing areas that are clear of coral, hard bottom substrate, and obstructions. LCAC landing and departure activities would be scheduled at high tide. In addition, LCACs would stay fully on cushion or hover when over shallow reef to avoid corals and hard bottom substrate. This is a standard operating procedure for safe operation of LCACs. Over-the-beach amphibious activity would only occur within designated areas based on the hydrographic and beach surveys. Similarly, AAV activities would only be scheduled within designated boat lanes and beach landing areas and would conduct their beach landings and departures at high tide one vehicle at a time within their designated boat lane (COMNAVMARINST 3500.4A). Based on the surveys, if the beach landing area and boat lane is clear, the activity could be conducted, and crews would follow procedures to avoid obstructions to navigation, including coral reefs; however, if there is any potential for impacts to occur on corals or hard bottom substrate, the Navy will coordinate with applicable resource agencies before conducting the activity. Hydrographic and beach surveys would not be necessary for beach landings with small boats, such as RHIBs.

The impact of vessels and in-water devices on marine invertebrates would be inconsequential because: (1) the area exposed to the stressor amounts to a small portion of each vessel's and in-water device's footprint, and is extremely small relative to most marine invertebrates' ranges; (2) the frequency of activities involving the stressor is low such that few individuals could be exposed to more than one event; and (3) exposures would be localized, temporary, and would cease with the conclusion of the activity. Activities involving vessels and in-water devices are not expected to yield any behavioral changes or lasting effects on the survival, growth, recruitment, or reproduction of invertebrate species at the population level.

Pursuant to the ESA, vessel or in-water device strikes or physical disturbance from training activities as described under Alternative 2 may affect ESA-listed coral species.

Testing Activities

Alternative 2 would include an incremental increase above Alternative 1 testing activities. Exposure of marine invertebrates to vessel disturbance and strikes would be limited to organisms in the water column, and primarily in the uppermost portions of the water column. Species that do not occur near the surface within the Study Area—including ESA-listed coral species—would not be exposed to vessel strikes. Most pelagic marine invertebrates are disturbed as the water flows around the vessel, towed in-water device, or autonomous vehicle. Injury or mortality caused directly or indirectly by propellers is possible, but the scale of impacts would be limited, and population-level impacts are unlikely. Seafloor invertebrates, including sessile ESA-listed coral species, are not likely to be exposed to this sub-stressor. The larval stage of corals existing as part of the plankton within the water column may be disturbed by vessels or in-water devices.

The impact of vessels and in-water devices on marine invertebrates would be inconsequential because: (1) the area exposed to the stressor amounts to a small portion of each vessel's and in-water device's footprint, and is extremely small relative to most marine invertebrates' ranges; (2) the frequency of activities involving the stressor is low such that few individuals could be exposed to more than one event; and (3) exposures would be localized, temporary, and would cease with the conclusion of the activity. Activities involving vessels and in-water devices are not expected to yield any behavioral changes or lasting effects on the survival, growth, recruitment, or reproduction of invertebrate species at the population level.

Pursuant to the ESA, vessel or in-water device strikes or physical disturbance from testing activities as described under Alternative 2 may affect ESA-listed coral species.

3.8.3.3.1.4 Substressor Impact on Sedentary Invertebrate Beds and Reefs as Essential Fish Habitat (Preferred Alternative)

Pursuant to the EFH requirements of the Magnuson-Stevens Fishery Conservation and Management Act and implementing regulations, the use of vessels and in-water devices during training and testing activities will have no effect on sedentary invertebrate beds or reefs that constitute EFH or Habitat Areas of Particular Concern within the Study Area.

3.8.3.3.2 Impacts from Military Expended Materials

This section analyzes the strike potential to marine invertebrates of the following categories of military expended materials: (1) non-explosive practice munitions; (2) fragments from high-explosive munitions; and (3) expended materials other than ordnance, such as sonobuoys, vessel hulks, and expendable targets. For a discussion of the types of activities that use military expended materials, where they are used, and how many activities would occur under each alternative, see Section 3.0.5.2.3.4 (Military Expended Materials).

The spatial extent of military expended materials deposition includes all of the Study Area. Despite this broad range, the majority of military expended materials deposition occurs within specific range complexes, such as Special Use Airspace and operating areas. These areas of higher military expended materials deposition are generally away from the coastline.

Chaff and flares include canisters, end-caps, and aluminum-coated glass fibers. Chaff, in particular, may be transported great distances by the wind, beyond the areas where they are deployed before contacting the sea surface. These materials contact the sea surface and seafloor with very little kinetic energy, and their low buoyant weight makes them an inconsequential strike and abrasion risk. Aerial countermeasures, therefore, will not be addressed as potential strike and disturbance stressors.

Physical disturbance or strikes by military expended materials on marine invertebrates is possible at the water's surface, through the water column, and at the seafloor. Disturbance or strike impacts on marine invertebrates by military expended materials falling through the water column is possible but not very likely because their kinetic energy dissipates within a few feet of the sea surface and they 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 will focus on military expended materials on the water's surface and the seafloor.

Sessile marine invertebrates and infauna are susceptible to military expended material strikes, particularly shallow-water corals, hardbottom, and deep-water corals. Most shallow-water coral reefs in the Study Area are within or adjacent to land masses, where expended materials are primarily lightweight flares and chaff, which have inconsequential strike potential.

3.8.3.3.2.1 Military Expended Materials that are Ordnance

Small-, Medium-, and Large-Caliber Projectiles

Various types of projectiles could cause a temporary local impact when they strike the surface of the water. Navy training and testing in the Study Area, such as gunnery exercises, include firing a variety of weapons and using a variety of non-explosive training and testing rounds, including and small-, medium, and large-caliber projectiles. With the exception of terrestrial based activities at FDM, the larger-caliber projectiles are primarily used in the open ocean beyond 12 nm from shore.

Direct ordnance strikes from firing weapons are potential strike stressors to marine invertebrates. Military expended materials have the potential to impact the water with great force. Physical disruption of the water column is a localized, temporary impact and would be limited to within tens of meters of the impact area, persisting for a matter of minutes. Physical and chemical properties of the surrounding water would be temporarily altered (e.g., slight heating or cooling and increased oxygen concentrations due to turbulent mixing with the atmosphere), but there would be no lasting change resulting in long-term impacts on marine invertebrates. Although the sea surface is rich with invertebrates, most are zooplankton and relatively few are large pelagic invertebrates (e.g., some jellyfish and some swimming crabs). Zooplankton, eggs and larvae, and larger pelagic organisms in the upper portions of the water column could be displaced, injured, or killed by military expended materials impacting the sea surface. Individual organisms would be impacted directly or indirectly, but not to the extent that the viability of populations or species would be impacted, primarily because the number of organisms exposed to these devices is extremely small relative to population sizes.

Marine invertebrate communities and individuals at various stages of development (eggs, larvae, or adults) would be exposed to munitions, including small-, medium-, and large-caliber projectiles. Marine invertebrates on the seafloor could be displaced, injured, or killed by military expended materials contacting the seafloor.

Potential impacts of projectiles on marine invertebrates, including shallow-water, hardbottom, or deep-water corals, present the greatest risk of long-term damage compared with other seafloor communities because (1) many corals and hardbottom invertebrates are sessile, fragile, and particularly vulnerable; (2) many of these organisms grow slowly, and could require decades to recover (Precht et al. 2001); and (3) military expended materials are likely to remain mobile for a longer period because natural encrusting and burial processes are much slower on these habitats than on hardbottom habitats.

Bombs, Missiles, and Rockets

Bombs, missiles, and rockets are potential strike stressors to marine invertebrates. The nature of their potential impacts is the same as projectiles. However, they are addressed separately because they are larger than most projectiles, and because high-explosive bombs, missiles, and rockets are likely to produce a greater number of small fragments than projectiles. Propelled fragments are produced by explosives. Close to the explosive, invertebrates could be injured by propelled fragments. However, studies of underwater bomb blasts have shown that fragments are larger than those produced during air blasts and decelerate much more rapidly (O'Keefe and Young 1984; Swisdak Jr. and Montaro 1992), reducing the risk to marine organisms. Bombs, missiles, and rockets are designed to explode within 3 ft. (1.01 m) of the sea surface where invertebrates are relatively infrequent. The fitness of individual organisms would be impacted directly or indirectly, but not to the extent that the viability of populations or species would be impacted, primarily because the number of organisms exposed to these devices would be extremely small relative to population sizes.

3.8.3.3.2.2 Military Expended Materials Other than Ordnance

Vessel Hulk

During a sinking exercise, aircraft, ship, and submarine crews deliver ordnance on a surface target, which is a clean (Section 3.1, Sediments and Water Quality) deactivated ship that is deliberately sunk using multiple weapon systems. Sinking exercises occur in specific open ocean areas, outside of the coastal range complexes. Ordnance strikes by the various weapons used in these exercises are a potential source of impacts. However, these impacts are discussed for each of those weapons categories in this section and are not repeated here. Therefore, the analysis of sinking exercises as a strike potential for benthic invertebrates is discussed in terms of the ship hulk landing on the seafloor. The primary difference between a vessel hulk and other military expended materials as a strike potential for marine invertebrates is a difference in scale. As the vessel hulk settles on the seafloor, all marine invertebrates within the footprint of the hulk would be impacted by strike or burial, and invertebrates a short distance beyond the footprint of the hulk would be disturbed. A deposited vessel hulk will potentially change local flow patterns, which could impact food delivery, patterns of sediment deposition and erosion, patterns of predation based on halo effects of predators around the vessel, and community changes based on new hard substratum high in the flow field off the seafloor. Habitat-forming invertebrates are likely absent where sinking exercises are planned because this activity occurs in depths greater than the range of corals and most other habitat-forming invertebrates (approximately 10,000 ft. [3,048 m]). It is possible that deep-sea corals may be impacted by a sinking vessel hulk or fragments of a hulk, but the size of the impact on the seafloor relative to the relatively broad distribution of deep sea corals suggests that these impacts would seldom occur.

Decelerators/Parachutes

Decelerators/Parachutes of varying sizes are used during training and testing activities. Sonobuoys, lightweight torpedoes, anti-submarine warfare training targets, and other devices deployed by aircraft use nylon decelerators/parachutes of various sizes. Decelerators/parachutes are made of cloth and nylon, and many have weights attached to the lines for rapid sinking. At water impact, the decelerator/parachute assembly is expended, and it sinks away from the unit. The decelerator/parachute assembly may remain at the surface for 5–15 seconds before the decelerator/parachute and its housing sink to the seafloor, where it becomes flattened (Section 3.0.5.2.4.2, Decelerators/Parachutes). Activities that expend sonobuoys and air-launched torpedo parachutes generally occur in water deeper than 183 m (600.4 ft.). Because they are in the air and water column for a time span of minutes, it is improbable that such a decelerator/parachute deployed over water deeper than 183 m (600.4 ft.) could travel far enough to affect shallow-water corals, including ESA-listed coral species. Movement of the decelerator/parachute in the water may break more fragile invertebrates such as deep-water corals.

3.8.3.3.2.3 No Action Alternative

Training Activities

Under the No Action Alternative, several different types of military expended materials with a potential for striking marine invertebrates are expended annually in the Study Area, as grouped below (Tables 3.0-18, 3.0-19, and 3.0-22):

- **Bombs:** Under the No Action Alternative, 32 explosive bombs and 522 non-explosive bombs would be expended during training activities in areas farther than 50 nm from shore. Additionally, 2,150 explosive bombs and 2,800 non-explosive bombs would be expended on the range at FDM.
- **Small-caliber projectiles:** Under the No Action Alternative, 60,000 small-caliber projectiles would be expended during training activities. These small-caliber projectiles would be expended throughout the Study Area. Additionally, 2,900 small caliber projectiles would be expended on the range at FDM.
- **Medium-caliber projectiles:** Under the No Action Alternative, 26,500 non-explosive, medium-caliber projectiles would be expended during training activities in areas farther than 3 nm from shore. Additionally, 21,500 explosive, medium-caliber projectiles would be expended on the range at FDM.
- **Large-caliber projectiles:** Under the No Action Alternative, 1,240 explosive, large-caliber projectiles would be expended during training activities in areas farther than 12 nm from shore. Additionally, 1,000 explosive large-caliber projectiles would be expended on the range at FDM.
- **Missiles:** Under the No Action Alternative, 58 explosive missiles would be expended during training activities in areas farther than 12 nm from shore. Additionally, 60 missiles would be expended on the range at FDM.
- **Sonobuoys:** Under the No Action Alternative, 8,065 non-explosive and 8 explosive sonobuoys would be used in areas farther than 3 nm from shore.
- **Decelerators/parachutes:** Under the No Action Alternative, 8,032 decelerators/parachutes would be expended during training activities in areas farther than 3 nm from shore throughout the Study Area.

Bombs, missiles, rockets, projectiles, and associated fragments may strike marine invertebrates, including zooplankton, eggs, and larvae, at the sea surface or on the seafloor. Consequences of strike or disturbance could include injury or mortality, particularly within the footprint of the object as it contacts the seafloor. Individual organisms could be impacted directly or indirectly, but not to the extent that the viability of populations or species would be impacted, primarily because the number of organisms exposed to these devices is extremely small relative to population sizes. The exceptions to this are corals (potentially including proposed coral species), which would be susceptible to abrasion injury, breakage, or mortality from fragments striking or settling upon the coral. Because these organisms are habitat-forming and also constitute some habitat areas of particular concern, these same impacts could degrade habitat quality. Individual organisms would be impacted directly or indirectly to the extent that the viability of populations or species would be impacted. However, as indicated in Chapter 2 (Description of Proposed Action and Alternatives), with the exception of those used on FDM, projectiles are used greater than 3 nm from the shore, and typically greater than 12 nm from shore, within the Study Area. At these distances from shore, the overlap between the area potentially impacted and areas containing coral habitat is extremely low. In the nearshore areas of FDM, some corals could be exposed if shore targets are missed. Intact bombs and other ordnance items, as well as munition and associated fragments, could strike ESA-listed coral species in the FDM nearshore environment. Any ESA-listed coral species present in the FDM nearshore environment could be subject to injury or mortality. Fitness of individual organisms would be impacted directly or indirectly, but not to the extent that the viability of populations or species would be impacted, primarily because the number of organisms impacted would be extremely small relative to population sizes.

During sinking exercises, pelagic invertebrates present near the water’s surface in the immediate vicinity of the exercise could potentially be injured or killed. Sinking exercise vessel hulks contacting the seafloor would result in mortality of marine invertebrates within the footprint of the hulk and disturbance of marine invertebrates near the footprint of the hulk. Sinking exercises may result in injury or mortality of marine invertebrates near the footprint of the hulk. Though the footprint of a sinking exercise is large relative to other military expended materials, the impacted area is extremely small relative to the spatial distribution of marine invertebrate populations as the location of a sinking exercise would not overlap with known coral habitats. Consequences of sinking exercises would impact individual organisms directly or indirectly, but not to the extent that the viability of populations or species would be measurably impacted.

Activities occurring at depths less than 2,600 ft. (800 m) may impact deep-water corals and other marine invertebrate assemblages. Consequences may include breakage, injury, or mortality as a result of projectiles or munitions (see Section 3.3, Marine Habitats). Decelerators/parachutes may cause abrasion injury or mortality, or breakage. Because these organisms are habitat-forming and also constitute some habitat areas of particular concern, these same impacts could degrade habitat quality. Individual organisms would be impacted directly or indirectly to the extent that the viability of populations or species would be impacted.

The impact of military expended materials on marine invertebrates is likely to cause injury or mortality to individuals, but impacts to populations would be inconsequential because: (1) the area exposed to the stressor is extremely small relative to most marine invertebrates’ ranges, (2) the activities are dispersed such that few individuals could conceivably be exposed to more than one event, and (3) exposures would be localized and would cease when the military expended material stops moving. Activities involving military expended material are not expected to yield any behavioral changes or lasting effects on the survival, growth, recruitment, or reproduction of invertebrate species at the population level. However, the combined consequences of all military expended materials could degrade habitat quality.

Pursuant to the ESA, the use of military expended materials may affect ESA-listed coral species. Pursuant to the ESA, the use of military expended materials on FDM may affect ESA-listed coral species as a result of direct strikes from off island munitions.

Testing Activities

Under the No Action Alternative, no military expended materials are deposited in the Study Area from testing activities.

3.8.3.3.2.4 Alternative 1

Training Activities

Under Alternative 1, several different types of military expended materials with a potential for striking marine invertebrates would be expended in the Study Area annually (see Table 2.8-1 and Tables 3.0-18, 3.0-19, and 3.0-22 for additional detail), as grouped below:

- **Bombs:** Under Alternative 1, 212 explosive bombs and 848 non-explosive bombs would be expended during training activities in areas farther than 50 nm from shore. Additionally, 6,242 explosive bombs and 2,670 non-explosive bombs would be expended on the range at FDM.
- **Small-caliber projectiles:** Under Alternative 1, approximately 86,000 non-explosive, small-caliber projectiles would be expended annually during training and testing activities in areas farther than 3 nm from shore. Additionally, approximately 42,000 small-caliber projectiles would be expended on the range at FDM.
- **Medium-caliber projectiles:** Under Alternative 1, approximately 85,500 non-explosive, medium-caliber projectiles and 8,500 explosive, medium-caliber projectiles would be expended annually during training activities in areas farther than 3 nm from shore. Additionally, 17,350 explosive and 94,150 non-explosive, medium-caliber projectiles would be expended on the range at FDM.
- **Large-caliber projectiles:** Under Alternative 1, 1,300 explosive, large-caliber projectiles and over 5,200 non-explosive large-caliber projectiles would be expended annually during training activities in areas farther than 12 nm from shore. Additionally, approximately 1,200 explosive, large-caliber projectiles and 1,800 non-explosive large-caliber projectiles would be expended on the range at FDM.
- **Missiles:** Under Alternative 1, 125 explosive missiles would be expended during training activities in areas farther than 12 nm from shore. Additionally, approximately 85 explosive, missiles would be expended on the range at FDM.
- **Rockets:** Under Alternative 1, 114 explosive rockets would be expended during training activities in areas farther than 12 nm from shore. Additionally, 2,000 explosive rockets would be expended on the range at FDM.
- **Sonobuoys:** Under the Alternative 1, 10,980 non-explosive and 11 explosive sonobuoys would be used in areas farther than 3 nm from shore.
- **Decelerators/parachutes:** Under Alternative 1, 10,845 decelerators/parachutes would be expended. Decelerators/parachutes associated with the use of air-launched torpedoes and sonobuoys would be expended in areas farther than 3 nm from shore throughout the Study Area.

Alternative 1 would include multi-fold increases in small- and medium-caliber projectiles. Bombs, missiles, rockets, projectiles, and associated fragments could strike zooplankton, eggs, or larvae at the sea surface or on the seafloor. Consequences of strike or disturbance could include injury or mortality, particularly within the footprint of the object as it contacts the seafloor. Individual organisms could be impacted directly or indirectly, but not to the extent that the viability of populations or species would be impacted, primarily because the number of organisms exposed to these devices is extremely small relative to population sizes. Additionally, as indicated in Chapter 2 (Description of Proposed Action and Alternatives), other than those used at FDM, projectiles are used greater than 3 nm from the shore, and typically greater than 12 nm from shore, within the Study Area. At these distances from shore, the overlap between the area potentially impacted and areas containing coral habitat is extremely low.

In the nearshore areas of FDM, some corals could be exposed if shore targets are missed. Intact bombs and other ordnance items, as well as munition and associated fragments, could strike ESA-listed coral species in the FDM nearshore environment. Any ESA-listed coral species present in the FDM nearshore environment could be subject to injury or mortality. Fitness of individual organisms would be impacted directly or indirectly, but not to the extent that the viability of populations or species would be impacted, primarily because the number of organisms impact would be extremely small relative to population sizes.

Sinking exercises may result in injury or mortality of marine invertebrates near the footprint of the hulk. Though the footprint of a sinking exercise is large relative to other military expended materials, the impacted area is extremely small relative to the spatial distribution of marine invertebrate populations. Consequences of sinking exercises would impact individual organisms directly or indirectly, but not to the extent that the viability of populations or species would be measurably impacted.

Activities occurring at depths less than 2,600 ft. (800 m) may impact deep-water corals and other marine invertebrate assemblages. Consequences may include breakage, injury, or mortality as a result of projectiles or munitions. Decelerators/parachutes may cause abrasion injury or mortality, or breakage. Because these organisms are habitat-forming and also constitute some habitat areas of particular concern, these same impacts could degrade habitat quality. Individual organisms would be impacted directly or indirectly to the extent that the viability of populations or species would be impacted.

Although the number of military expended materials would increase under Alternative 1 compared to the No Action Alternative, the types of impacts would be similar to those described under the No Action Alternative. The probability of military expended material strikes on marine invertebrates, however, would increase because of the increase in the number of military expended materials. Activities involving military expended materials are not expected to yield any behavioral changes or lasting effects on the survival, growth, recruitment, or reproduction of invertebrate species at the population level. However, the combined consequences of all military expended materials could degrade habitat quality.

Pursuant to the ESA, the use of military expended materials may affect ESA-listed coral species. The use of military expended materials on FDM may affect ESA-listed coral species as a result of direct strikes from off island munitions.

Testing Activities

Under Alternative 1, 2,000 small caliber rounds, 2,040 non-explosive medium caliber rounds, 1,680 non-explosive large caliber rounds, 20 non-explosive missiles, 932 non-explosive sonobuoys, and 1,727 decelerators/parachutes would be used during testing activities, and those items would be expended in areas farther than 3 nm from shore in the Study Area. Approximately 13,781 explosives would be used for testing activities under Alternative 1 (2,040 explosive medium caliber rounds, 10,920 in-air explosive large caliber rounds, 20 explosive missiles, 8 explosive torpedoes, 793 explosive sonobuoys).

Missiles, rockets, projectiles, and associated fragments could strike zooplankton, eggs, or larvae at the sea surface or on the seafloor. Consequences of strike or disturbance could include injury or mortality, particularly within the footprint of the object as it contacts the seafloor. Individual organisms could be impacted directly or indirectly, but not to the extent that the viability of populations or species would be impacted, primarily because the number of organisms exposed to these devices is extremely small relative to population sizes. As indicated in Chapter 2 (Description of Proposed Action and Alternatives), projectiles are used greater than 3 nm from the shore, and typically greater than 12 nm from shore, within the Study Area. At these distances from shore, the overlap between the area potentially impacted and areas containing ESA-listed coral species is extremely low.

Consequences of strikes or disturbances could include injury or mortality, particularly within the footprint of the object as it contacts the seafloor. The fitness (ability to produce offspring) of individual organisms would be impacted directly or indirectly, but not to the extent that the viability of populations or species would be impacted, primarily because the number of organisms exposed to these devices would be extremely small relative to population sizes.

Although the number of military expended materials would increase under Alternative 1 compared to the No Action Alternative, the types of impacts would be similar to those described under the No Action Alternative. The probability of military expended material strikes on marine invertebrates, however, would increase because of the increase in the number of military expended materials. Activities involving military expended materials are not expected to yield any behavioral changes or lasting effects on the survival, growth, recruitment, or reproduction of invertebrate species at the population level. However, the combined consequences of all military expended materials could degrade habitat quality.

Pursuant to the ESA, the use of military expended materials may affect ESA-listed coral species.

3.8.3.3.2.5 Alternative 2

Training Activities

Under Alternative 2, the Navy proposes the same numbers and types of military expended materials as described in Alternative 1 with the exception of non-explosive medium-caliber projectiles, targets, rockets (explosive), and missiles, which will increase from Alternative 1 to 85,750, 426, 380, and 125 (explosive), respectively (Table 3.0-18, 3.0-19, and 3.0-22). With only slight increases from those of Alternative 1, the impacts of Alternative 2 training activities on marine invertebrates would be the same as for Alternative 1.

Pursuant to the ESA, the use of military expended materials may affect ESA-listed coral species. The use of military expended materials on FDM may affect ESA-listed coral species as a result of direct strikes from off island munitions.

Testing Activities

Under Alternative 2, 2,500 small caliber rounds, 2,490 non-explosive medium-caliber rounds, 2,100 non-explosive large-caliber rounds, 27 non-explosive missiles, 1,025 non-explosive sonobuoys, and 1,912 decelerators/parachutes would be used during testing activities, and those items would be expended in areas greater than 3 nm from shore in the Study Area. Approximately 2,490 explosive medium caliber rounds, 12,100 in-air explosive large caliber rounds, 25 explosive missiles, 8 explosive torpedoes, and 884 explosive sonobuoys would be used for testing activities under Alternative 2.

Missiles, rockets, projectiles, and associated fragments could strike zooplankton, eggs, or larvae at the sea surface or on the seafloor. Consequences of strike or disturbance could include injury or mortality, particularly within the footprint of the object as it contacts the seafloor. Individual organisms could be impacted directly or indirectly, but not to the extent that the viability of populations or species would be impacted, primarily because the number of organisms exposed to these devices is extremely small relative to population sizes. As indicated in Chapter 2 (Description of Proposed Action and Alternatives), projectiles are used greater than 3 nm from the shore, and typically greater than 12 nm from shore, within the Study Area. At these distances from shore, the overlap between the area potentially impacted and areas containing ESA-listed coral species is extremely low.

Consequences of strikes or disturbances could include injury or mortality, particularly within the footprint of the object as it contacts the seafloor. The fitness (ability to produce offspring) of individual organisms would be impacted directly or indirectly, but not to the extent that the viability of populations or species would be impacted, primarily because the number of organisms exposed to these devices would be extremely small relative to population sizes.

Although the number of military expended materials would increase under Alternative 1 compared to the No Action Alternative, the types of impacts would be similar to those described under the No Action Alternative. The probability of military expended material strikes on marine invertebrates, however, would increase because of the increase in the number of military expended materials. Activities involving military expended materials are not expected to yield any behavioral changes or lasting effects on the survival, growth, recruitment, or reproduction of invertebrate species at the population level. However, the combined consequences of all military expended materials could degrade habitat quality.

Pursuant to the ESA, the use of military expended materials may affect ESA-listed coral species.

3.8.3.3.2.6 Substressor Impact on Sedentary Invertebrate Beds and Reefs as Essential Fish Habitat (Preferred Alternative)

Pursuant to the EFH requirements of the Magnuson-Stevens Fishery Conservation and Management Act and implementing regulations, the use of military expended materials during training and testing activities may have an adverse effect on EFH by reducing the quality or quantity of sedentary invertebrate beds or reefs that constitute EFH or Habitat Areas of Particular Concern. The EFHA states that the impact to sedentary invertebrate beds would be minimal and long-term to permanent in duration (based on substrate impacts), whereas impacts to reefs would be individually minimal and permanent in duration within the Study Area.

3.8.3.3.3 Impacts from Seafloor Devices

Seafloor devices include items that are placed on, dropped on, or moved along, the seafloor, such as mine shapes, anchor blocks or anchors (such as those associated with the Portable Undersea Training Range [PUTR]) that are placed on the substrate for a specific purpose. Deployment of seafloor devices would cause disturbance, injury, or mortality within the footprint of the device, may disturb marine invertebrates outside the footprint of the device, and would cause temporary local increases in turbidity near the ocean bottom. Objects placed on the seafloor may attract invertebrates, or provide temporary attachment points for invertebrates. Some invertebrates attached to the devices would be removed from the habitat when the devices are recovered. A shallow depression may remain in the soft bottom sediment where an anchor was dropped.

3.8.3.3.3.1 No Action Alternative

Training Activities

Table 3.0-21 presents the number and types of training activities involving seafloor devices. Under the No Action Alternative, 44 events involving seafloor devices occur annually. These events are related to mine warfare and PUTR activities. These involve the placement of up to 480 mine shapes on the sea floor within Warning Area-517 and placement of anchor blocks within the MITT Study Area, respectively. The impact of seafloor devices on marine invertebrates is likely to cause injury or mortality to individuals, but impacts to populations would be inconsequential because: (1) the area exposed to the stressor is extremely small relative to most marine invertebrates' ranges, (2) the activities are dispersed such that few individuals could conceivably be exposed to more than one activity, and (3) exposures would be localized. Activities involving seafloor devices are not expected to yield any behavioral changes or lasting impacts on the survival, growth, recruitment, or reproduction of invertebrate species at the population level.

Pursuant to the ESA, physical disturbance and strikes by seafloor devices associated with training activities as described under the No Action Alternative would have no effect on ESA-listed coral species.

Testing Activities

Under the No Action Alternative, seafloor devices are only utilized during testing activities at the North Pacific Acoustic Lab's Deep Water site, which would occur once per year. The deep water experimental site (> 1,000 m deep [> 3,281 ft.]) consists of an acoustic tomography array, a distributed vertical line array, and moorings in the deep-water environment of the northwestern Philippine Sea, which is not known to support shallow-water corals. The impact of seafloor devices on marine invertebrates is likely to cause injury or mortality to individuals, but impacts to populations would be inconsequential because: (1) the area exposed to the stressor is extremely small relative to most marine invertebrates' ranges, and (2) the activities and subsequent exposures would be localized. Activities involving seafloor devices associated with testing activities are not expected to yield any behavioral changes or lasting impacts on the survival, growth, recruitment, or reproduction of invertebrate species at the population level.

Pursuant to the ESA, physical disturbance and strikes by seafloor devices associated with testing activities as described under the no Action Alternative would have no effect on ESA-listed coral species.

3.8.3.3.3.2 Alternative 1

Training Activities

Table 3.0-21 presents the number and types of training activities involving seafloor devices. Under the Alternative 1, 136 events involving seafloor devices occur annually. Mine laying activities involve the placement of up to 480 mine shapes on the sea floor within MIRC warning areas. Other items encountering the sea floor include moored mine shapes, anchors, bottom placed instruments, and robotic vehicles referred to as "crawlers," which are typically placed in soft-bottom areas that do not overlap with areas that support coral species. These items are primarily used in mine warfare and anti-submarine warfare activities.

Seafloor devices are either stationary or move very slowly along the bottom and do not pose a threat to highly mobile organisms. The impact of seafloor devices on marine invertebrates is likely to cause injury or mortality to individuals, but impacts to populations would be inconsequential because: (1) the area exposed to the stressor is extremely small relative to most marine invertebrates' ranges, (2) the activities are dispersed such that few individuals could conceivably be exposed to more than one activity, and (3) exposures would be localized. Activities involving seafloor devices are not expected to yield any behavioral changes or lasting impacts on the survival, growth, recruitment, or reproduction of invertebrate species at the population level.

Pursuant to the ESA, physical disturbance and strikes by seafloor devices associated with training activities as described under Alternative 1 would have no effect on ESA-listed coral species.

Testing Activities

Under Alternative 1, seafloor devices are utilized during pierside integrated swimmer defense activities within inner Apra Harbor, MCM mission package testing, and testing activities at the North Pacific Acoustic Lab's Deep Water site. The Inner Apra Harbor and North Pacific Acoustic Lab sites are located in areas that are not known to support shallow-water coral species, the first being a highly disturbed area, and the second being a deep water site. The deep water experimental site consists of an acoustic tomography array, a distributed vertical line array, and moorings in the deep-water environment (depths greater than 3,280 ft. [1,000 m]) of the northwestern Philippine Sea and would occur once per year. MCM Mission Package testing would occur up to 32 times per year throughout the Study Area. Pierside integrated swimmer defense activities would occur up to 11 times per year.

The impact of seafloor devices on marine invertebrates could cause injury or mortality to individuals, but impacts to populations would be inconsequential because: (1) the area exposed to the stressor is extremely small relative to most marine invertebrates' ranges, (2) the activities are dispersed such that few individuals could conceivably be exposed to more than one event, and (3) the activities and subsequent exposures would be localized. Activities involving seafloor devices associated with testing activities are not expected to yield any behavioral changes or lasting impacts on the survival, growth, recruitment, or reproduction of invertebrate species at the population level.

Pursuant to the ESA, physical disturbance and strikes by seafloor devices associated with testing activities as described under Alternative 1 would have no effect on ESA-listed coral species.

3.8.3.3.3.3 Alternative 2

Training Activities

Table 3.0-21 presents the number and types of training activities involving seafloor devices. Under the Alternative 2, 136 events involving seafloor devices occur annually. Sea floor items include moored mine shapes, anchors, bottom placed instruments, and robotic vehicles referred to as "crawlers," which are typically placed in soft-bottom areas that do not overlap with areas that support coral species. Seafloor devices are either stationary or move very slowly along the bottom and do not pose a threat to highly mobile organisms. The impact of seafloor devices on marine invertebrates is likely to cause injury or mortality to individuals, but impacts to populations would be inconsequential because: (1) the area exposed to the stressor is extremely small relative to most marine invertebrates' ranges, (2) the activities are dispersed such that few individuals could conceivably be exposed to more than one activity, and (3) exposures would be localized. Activities involving seafloor devices are not expected to yield any behavioral changes or lasting impacts on the survival, growth, recruitment, or reproduction of invertebrate species at the population level.

Pursuant to the ESA, physical disturbance and strikes by seafloor devices associated with training activities as described under Alternative 2 would have no effect on ESA-listed coral species.

Testing Activities

Under Alternative 2, seafloor devices are utilized during pierside integrated swimmer defense activities within inner Apra Harbor, MCM mission package testing, and testing activities at the North Pacific Acoustic Lab's Deep Water site. The Inner Apra Harbor and North Pacific Acoustic Lab sites are located in areas that are not known to support shallow-water coral species, the first being a highly disturbed area, and the second being a deep water site. The deep water experimental site consists of an acoustic tomography array, a distributed vertical line array, and moorings in the deep-water environment (depths greater than 3,280 ft. [1,000 m]) of the northwestern Philippine Sea and would occur once per year. MCM Mission Package testing would occur up to 36 times per year throughout the Study Area. Pierside integrated swimmer defense activities would occur up to 11 times per year.

The impact of seafloor devices on marine invertebrates could cause injury or mortality to individuals, but impacts to populations would be inconsequential because: (1) the area exposed to the stressor is extremely small relative to most marine invertebrates' ranges, (2) the activities are dispersed such that few individuals could conceivably be exposed to more than one event, and (3) the activities and subsequent exposures would be localized. Activities involving seafloor devices associated with testing activities are not expected to yield any behavioral changes or lasting impacts on the survival, growth, recruitment, or reproduction of invertebrate species at the population level.

Pursuant to the ESA, physical disturbance and strikes by seafloor devices associated with testing activities as described under Alternative 2 would have no effect on ESA-listed coral species.

3.8.3.3.3.4 Substressor Impact on Sedentary Invertebrate Beds and Reefs as Essential Fish Habitat (Preferred Alternative)

Pursuant to the EFH requirements of the Magnuson-Stevens Fishery Conservation and Management Act and implementing regulations, the use of seafloor devices during training and testing activities could have an adverse effect on sedentary invertebrate beds or reefs that constitute EFH or Habitat Areas of Particular Concern. The EFHA states that the impact to sedentary invertebrate beds (e.g., amphipod tubes, bryozoans) may be minimal and long-term.

3.8.3.4 Entanglement Stressors

This section analyzes the potential entanglement impacts of the various types of expended materials used by the Navy during training and testing activities within the Study Area. Included are potential impacts from two types of military expended materials: (1) fiber optic cables and guidance wires, and (2) decelerators/parachutes. Aspects of entanglement stressors that are applicable to marine organisms in general are presented in Section 3.0.5.2.4 (Entanglement Stressors).

Most marine invertebrates are less susceptible to entanglement than fishes, sea turtles, and marine mammals due to their size, behavior, and morphology. Because even fishing nets, which are designed to take marine invertebrates, operate by enclosing rather than entangling, marine invertebrates seem to be somewhat less susceptible than vertebrates to entanglement (Chuenpagdee et al. 2003; Morgan and Chuenpagdee 2003). A survey of marine debris entanglements found that marine invertebrates composed 16 percent of all animal entanglements (Ocean Conservancy 2010). The same survey cites potential entanglement in military items only in the context of waste-handling aboard ships, and not for military expended materials. Nevertheless, it is conceivable that marine invertebrates, particularly arthropods and echinoderms with rigid appendages, might become entangled in fiber optic cables and guidance wires and in decelerators/parachutes.

3.8.3.4.1 Impacts from Fiber Optic Cables and Guidance Wires

Fiber optic cables are only expended during airborne mine neutralization testing activities and torpedo guidance wires are used in training and testing activities involving heavyweight torpedoes. For a discussion of the types of activities that use guidance wires and fiber optic cables, physical characteristics of these expended materials, where they are used, and how many activities would occur under each alternative, please see Section 3.0.5.2.4.1 (Fiber Optic Cables and Guidance Wires). Abrasion and shading-related impacts on sessile benthic (attached to the seafloor) marine invertebrates that may result from entanglement stressors are discussed with physical impacts in Section 3.8.3.3 (Physical Disturbance and Strike Stressors).

A marine invertebrate that might become entangled could be only temporarily confused and escape unharmed, it could be held tightly enough that it could be injured during its struggle to escape, it could be preyed upon while entangled, or it could starve while entangled. The likelihood of these outcomes cannot be predicted with any certainty because interactions between invertebrate species and entanglement hazards are not well known. The potential entanglement scenarios are based on observations of how marine invertebrates are entangled in marine debris, which is far more prone to tangling than guidance wire or fiber optic cable (Environmental Sciences Group 2005; Ocean Conservancy 2010). The small number of guidance wires and fiber optic cables expended across the Study Area results in an extremely low rate of potential encounter for marine invertebrates.

3.8.3.4.1.1 No Action Alternative

Training Activities

As indicated in Table 2.8-1, under the No Action Alternative, torpedoes expending guidance wire would occur in throughout the Study Area during tracking exercises, all greater than 3 nm from the shore. Only 53 torpedoes and torpedo accessories would be used under the No Action Alternative (Table 3.0-18 and Table 3.0-19), and only heavyweight torpedoes utilize guidance wires (40; Table 3.0-24). Due to the location of the activities, only pelagic and deep water benthic invertebrates could be exposed to this substressor; therefore, there would be no overlap between activities and shallow-water corals—including ESA-listed coral species. Given the low numbers used, most marine invertebrates would never be exposed to guidance wire. However, if the guidance wires drifted to nearshore locations they could potentially entangle corals and cause abrasions, breakage, and potential mortality, though given the negatively buoyancy of these wires, this event is improbable.

The impact of guidance wires on marine invertebrates is not likely to cause injury or mortality to individuals, and impacts would be inconsequential because: (1) the area exposed to the stressor is extremely small relative to most marine invertebrates' ranges, (2) the activities are dispersed such that few individuals could conceivably be exposed to more than one activity, (3) exposures would be localized, and (4) marine invertebrates are not particularly susceptible to entanglement stressors as most would avoid entanglement and simply be temporarily disturbed. Activities involving fiber optic cables and guidance wires are not expected to yield any behavioral changes or lasting impacts on the survival, growth, recruitment, or reproduction of invertebrate species at individual or population levels.

Pursuant to the ESA, the use of fiber optic cables and guidance wires expended during training activities as described under the No Action Alternative would have no effect on ESA-listed coral species.

Testing Activities

Under the No Action Alternative, no events would occur that would expend fiber optic or guidance wires during testing events (Table 3.0-23 and Table 3.0-24).

3.8.3.4.1.2 Alternative 1

Training Activities

As indicated in Table 2.8-1, under Alternative 1, torpedoes expending guidance wire would occur throughout the Study Area during tracking exercises, all greater than 3 nm from the shore. Alternative 1 proposes a slight increase in the number of torpedoes used, 63, as compared to the 53 torpedoes and torpedo accessories that would be used under the No Action Alternative, though not all of these are heavyweight torpedoes, which utilize guidance wires (40, Table 3.0-24). Alternative 1 would also introduce the usage of 16 fiber optic cables annually (Table 3.0-23). Due to the location of the activities, only pelagic and deep water benthic invertebrates could be exposed to this sub-stressor, and only slightly more than the exposure under the No Action Alternative; therefore, there would be no overlap between activities and shallow-water corals—including ESA-listed coral species. Given the low numbers used, most marine invertebrates would never be exposed to a cable or guidance wire. However, if the guidance wires drifted to nearshore locations they could potentially entangle corals and cause abrasions, breakage, and potential mortality, though given the negatively buoyancy of these wires, this event is improbable.

The impact of fiber optic cables and guidance wires on marine invertebrates is not likely to cause injury or mortality to individuals, and impacts would be inconsequential because: (1) the area exposed to the stressor is extremely small relative to most marine invertebrates' ranges, (2) the activities are dispersed such that few individuals could conceivably be exposed to more than one activity, (3) exposures would be localized, and (4) marine invertebrates are not particularly susceptible to entanglement stressors as most would avoid entanglement and simply be temporarily disturbed. Activities involving cables and guidance wires are not expected to yield any behavioral changes or lasting impacts on the survival, growth, recruitment, or reproduction of invertebrate species at individual or population levels.

Pursuant to the ESA, the use of fiber optic cables and guidance wires expended during training activities as described under Alternative 1 would have no effect on ESA-listed coral species.

Testing Activities

Under Alternative 1, 60 torpedoes are utilized throughout the Study Area during torpedo testing (Table 3.0-24) though only 20 of those are heavyweight torpedoes that utilize guidance wires. Additionally, MCM Mission Package testing (Table 2.8-3) expends up to 48 fiber optic cables. All testing activities involving fiber optic cables and guidance wires would occur greater than 3 nm from the shore. Due to the location of the activities, only pelagic and deep water benthic invertebrates could be exposed to this stressor. There would be no overlap between activities and shallow-water corals—including ESA-listed coral species. Given the low numbers used, most marine invertebrates would never be exposed to a fiber optic cables or guidance wire from testing activities. However, if the guidance wires drifted to nearshore locations they could potentially entangle corals and cause abrasions, breakage, and potential mortality, though given the negatively buoyancy of these wires, this event is improbable.

The impact of fiber optic cables and guidance wires on marine invertebrates is not likely to cause injury or mortality to individuals, and impacts would be inconsequential because: (1) the area exposed to the stressor is extremely small relative to most marine invertebrates' ranges, (2) the activities are dispersed such that few individuals could conceivably be exposed to more than one activity, (3) exposures would be localized, and (4) marine invertebrates are not particularly susceptible to entanglement stressors as most would avoid entanglement and simply be temporarily disturbed. Activities involving fiber optic cables and guidance wires are not expected to yield any behavioral changes or lasting impacts on the survival, growth, recruitment, or reproduction of invertebrate species at individual or population levels.

Pursuant to the ESA, the use of fiber optic cables and guidance wires expended during testing activities as described under Alternative 1 would have no effect on ESA-listed coral species.

3.8.3.4.1.3 Alternative 2

Training Activities

The number and location of training activities under Alternative 2 are identical to training activities under Alternative 1. Therefore, impacts and comparisons to the No Action Alternative will also be identical as described for Alternative 1.

Pursuant to the ESA, the use of fiber optic cables and guidance wires expended during training activities as described under Alternative 2 would have no effect on ESA-listed coral species.

Testing Activities

Under Alternative 2, 70 torpedoes would be used throughout the Study Area though only 20 of those are heavyweight torpedoes that utilize guidance wires (Table 3.0-24). Additionally, MCM Mission Package testing (Table 2.8-3) expends up to 56 fiber optic cables. All testing activities involving fiber optic cables and guidance wires would occur greater than 3 nm from the shore. Due to the location of the activities, only pelagic and deep water benthic invertebrates could be exposed to this stressor. There would be no overlap between activities and shallow-water corals—including ESA-listed coral species. Given the low numbers used, most marine invertebrates would never be exposed to a fiber optic cable or guidance wire from testing activities. However, if the guidance wires drifted to nearshore locations they could potentially entangle corals and cause abrasions, breakage, and potential mortality, though given the negatively buoyancy of these wires, this event is improbable.

The impact of fiber optic cables and guidance wires on marine invertebrates is not likely to cause injury or mortality to individuals, and impacts would be inconsequential because: (1) the area exposed to the stressor is extremely small relative to most marine invertebrates' ranges, (2) the activities are dispersed such that few individuals could conceivably be exposed to more than one activity, (3) exposures would be localized, and (4) marine invertebrates are not particularly susceptible to entanglement stressors as most would avoid entanglement and simply be temporarily disturbed. Activities involving fiber optic cables and guidance wires are not expected to yield any behavioral changes or lasting impacts on the survival, growth, recruitment, or reproduction of invertebrate species at individual or population levels.

Pursuant to the ESA, the use of fiber optic cables and guidance wires expended during testing activities as described under Alternative 2 would have no effect on ESA-listed coral species.

3.8.3.4.1.4 Substressor Impact on Sedentary Invertebrate Beds and Reefs as Essential Fish Habitat (Preferred Alternative)

Pursuant to the EFH requirements of the Magnuson-Stevens Fishery Conservation and Management Act and implementing regulations, the use of fiber optic cables and guidance wires during training and testing activities could have an adverse effect on sedentary invertebrate beds or reefs that constitute EFH or Habitat Areas of Particular Concern. The EFHA states that the impact to sedentary invertebrate beds (e.g., amphipod tubes, bryozoans) may be minimal and long-term.

3.8.3.4.2 Impacts from Decelerators/Parachutes

Decelerators/parachutes of varying sizes are used during training and testing activities. Sonobuoys, lightweight torpedoes, anti-submarine warfare training targets, and other devices deployed by aircraft use decelerators/parachutes that are made of cloth and nylon, and many have weights attached to the lines for rapid sinking. At water impact, the decelerator/parachute assembly is expended, and it sinks away from the unit. The decelerator/parachute assembly may remain at the surface for 5–15 seconds before the decelerator/parachute and its housing sink to the seafloor, where it becomes flattened (Section 3.0.5.2.4.2, Decelerators/Parachutes). Because they are in the air and water column for a time span of minutes, it is improbable that such a decelerator/parachute deployed in areas greater than 3 nm from shore (in water depths deeper than 183 m [600.4 ft.]) could travel far enough to affect shallow-water corals, including ESA-listed coral species. Movement of the decelerator/parachute in the water may break more fragile invertebrates such as deep-water corals which would also reduce suitable hard substrate for encrusting organisms. Deep-water coral species potentially occur everywhere that decelerator/parachute use occurs. The ESA-listed coral species are susceptible to entanglement in decelerators/parachutes, but the principal mechanism of damage is abrasion or breakage; therefore, this potential stressor is addressed in Section 3.8.3.2.2 (Impacts from Military Expended Materials).

Decelerators/parachutes pose a potential, though unlikely, entanglement risk to susceptible marine invertebrates. The most likely method of entanglement would be a marine invertebrate crawling through the fabric or cord that then would tighten around it. A marine invertebrate that might become entangled could be temporarily confused and escape unharmed, held tightly enough that it could be injured during its struggle to escape, preyed upon while entangled, or starved while entangled. The likelihood of these outcomes cannot be predicted with any certainty because interactions between invertebrate species and entanglement hazards are not well known. The potential entanglement scenarios are based on observations of how marine invertebrates are entangled in marine debris (Environmental Sciences Group 2005; Ocean Conservancy 2010). Filter-feeding invertebrates such as deep water corals and sponges could be entangled in the fabric and suffocate or starve.

3.8.3.4.2.1 No Action Alternative

<u>Training Activities</u>

Under the No Action Alternative, 8,032 decelerators/parachutes would be expended during training activities (Table 3.0-25) and would be expended in locations greater than 3 nm from shore throughout the Study Area (in water typically deeper than 183 m [600.4 ft.]). Because they are in the air and water column for a time span of minutes, it is improbable that such a decelerator/parachute deployed greater than 3 nm from shore could travel far enough to affect shallow-water corals, including ESA-listed coral species. Movement of the decelerator/parachute in the water may break more fragile invertebrates such as deep-water corals, which would also reduce suitable hard substrate for encrusting organisms. Filter-feeding invertebrates such as deep water corals and sponges could be entangled in the fabric and suffocate or starve.

Most marine invertebrates would never encounter a decelerator/parachute. The impact of decelerators/parachutes on marine invertebrates is not likely to cause injury or mortality to individuals, and impacts would be inconsequential because: (1) the area exposed to the stressor is extremely small relative to most marine invertebrates' ranges, (2) the activities are dispersed such that few individuals could conceivably be exposed to more than one activity, (3) exposures would be localized, and (4) marine invertebrates are not particularly susceptible to entanglement stressors as most would avoid entanglement and simply be temporarily disturbed. Activities involving decelerators/parachutes are not expected to yield any behavioral changes or lasting impacts on the survival, growth, recruitment, or reproduction of invertebrate species at individual or population levels.

Pursuant to the ESA, the use of decelerators/parachutes expended during training activities as described under the No Action Alternative would have no effect on ESA-listed coral species.

Testing Activities

Under the No Action Alternative, no testing activities that would create entanglement hazards from decelerators/parachutes are conducted in the Study Area.

3.8.3.4.2.2 Alternative 1

Training Activities

Under Alternative 1, 10,845 decelerators/parachutes would be expended (Table 3.0-25) during training activities. Decelerators/parachutes would be expended in areas greater than 3 nm from shore throughout the Study Area. Similar to the No Action Alternative, activities that expend sonobuoys and air-launched torpedo parachutes generally occur in water deeper than 183 m (600.4 ft.). Because they are in the air and water column for a time span of minutes, it is improbable that such a decelerator/parachute deployed over water deeper than 183 m (600.4 ft.) could travel far enough to affect shallow-water corals, including ESA-listed coral species. Movement of the decelerator/parachute in deeper water may break more fragile invertebrates such as deep-water corals which would also reduce suitable hard substrate for encrusting organisms. Filter-feeding invertebrates such as deep water corals and sponges could be entangled in the fabric and suffocate or starve.

Most marine invertebrates would never encounter a decelerator/parachute. The impact of decelerators/parachutes on marine invertebrates is not likely to cause injury or mortality to individuals, and impacts would be inconsequential because: (1) the area exposed to the stressor is extremely small relative to most marine invertebrates' ranges, (2) the activities are dispersed such that few individuals could conceivably be exposed to more than one activity, (3) exposures would be localized, and (4) marine invertebrates are not particularly susceptible to entanglement stressors as most would avoid entanglement and simply be temporarily disturbed. Activities involving decelerators/parachutes are not expected to yield any behavioral changes or lasting impacts on the survival, growth, recruitment, or reproduction of invertebrate species at individual or population levels.

Pursuant to the ESA, the use of decelerators/parachutes expended during training activities as described under Alternative 1 would have no effect on ESA-listed coral species.

Testing Activities

Under Alternative 1, 1,727 decelerators/parachutes would be expended (Table 3.0-25) during testing activities. Decelerators/parachutes would be expended in areas greater than 3 nm from shore throughout the Study Area. Activities that expend sonobuoys and air-launched torpedo parachutes generally occur in water deeper than 183 m (600.4 ft.). Because they are in the air and water column for a time span of minutes, it is improbable that such a decelerator/parachute deployed over water deeper than 183 m (600.4 ft.) could travel far enough to affect shallow-water corals, including ESA-listed coral species. Movement of the decelerator/parachute in the water may break more fragile invertebrates such as deep-water corals also reduce suitable hard substrate for encrusting organisms.

Most marine invertebrates would never encounter a decelerator/parachute from testing activities. The impact of decelerators/parachutes on marine invertebrates is not likely to cause injury or mortality to individuals, and impacts would be inconsequential because: (1) the area exposed to the stressor is extremely small relative to most marine invertebrates' ranges, (2) the activities are dispersed such that few individuals could conceivably be exposed to more than one activity, (3) exposures would be localized, and (4) marine invertebrates are not particularly susceptible to entanglement stressors as most would avoid entanglement and simply be temporarily disturbed. Activities involving decelerators/parachutes are not expected to yield any behavioral changes or lasting impacts on the survival, growth, recruitment, or reproduction of invertebrate species at individual or population levels.

Pursuant to the ESA, the use of decelerators/parachutes expended during testing activities as described under Alternative 1 would have no effect on ESA-listed coral species.

3.8.3.4.2.3 Alternative 2

Training Activities

The number and location of training activities under Alternative 2 are identical to training activities under Alternative 1. Therefore, impacts and comparisons to the No Action Alternative will also be identical.

Pursuant to the ESA, the use of decelerators/parachutes expended during training activities as described under Alternative 2 would have no effect on ESA-listed coral species.

Testing Activities

Under Alternative 2, 1,912 decelerators/parachutes would be expended (Table 3.0-25) during testing activities. Decelerators/parachutes would be expended in areas greater than 3 nm from shore throughout the Study Area. Activities that expend sonobuoys and air-launched torpedo parachutes generally occur in water deeper than 183 m (600.4 ft.). Because they are in the air and water column for a time span of minutes, it is improbable that such a decelerator/parachute deployed over water deeper than 183 m (600.4 ft.) could travel far enough to affect shallow-water corals, including ESA-listed coral species. Movement of the decelerator/parachute in the water may break more fragile invertebrates, such as deep-water corals, and also reduce suitable hard substrate for encrusting organisms.

Most marine invertebrates would never encounter a decelerator/parachute from testing activities. The impact of decelerators/parachutes on marine invertebrates is not likely to cause injury or mortality to individuals, and impacts would be inconsequential because: (1) the area exposed to the stressor is extremely small relative to most marine invertebrates' ranges, (2) the activities are dispersed such that few individuals could conceivably be exposed to more than one activity, (3) exposures would be localized, and (4) marine invertebrates are not particularly susceptible to entanglement stressors as most would avoid entanglement and simply be temporarily disturbed. Activities involving decelerators/parachutes are not expected to yield any behavioral changes or lasting impacts on the survival, growth, recruitment, or reproduction of invertebrate species at individual or population levels.

Pursuant to the ESA, the use of decelerators/parachutes expended during testing activities as described under Alternative 2 would have no effect on ESA-listed coral species.

3.8.3.4.2.4 Substressor Impact on Sedentary Invertebrate Beds and Reefs as Essential Fish Habitat (Preferred Alternative)

Pursuant to the EFH requirements of the Magnuson-Stevens Fishery Conservation and Management Act and implementing regulations, the use of decelerators/parachutes during training and testing activities could have an adverse effect on sedentary invertebrate beds or reefs that constitute EFH or Habitat Areas of Particular Concern. The EFHA states that the impact to sedentary invertebrate beds (e.g., amphipod tubes, bryozoans) may be minimal and long-term.

3.8.3.5 Ingestion Stressors

3.8.3.5.1 Impacts from Military Expended Materials

This section analyzes the potential ingestion impacts of the various types of military expended materials used by the Navy during training and testing activities within the Study Area. As presented in Section 3.0.5.2.5 (Ingestion Stressors), the Navy expends the following types of materials that could become ingestion stressors during training and testing in the Study Area: non-explosive practice munitions (small- and medium-caliber), fragments from explosives, fragments from targets, chaff, flare casings (including plastic end caps and pistons), and decelerators/parachutes. Other military expended materials such as targets, large-caliber projectiles, intact training and testing bombs, guidance wires, 55-gallon drums, sonobuoy tubes, and marine markers are too large for marine organisms to consume and are eliminated from further discussion. Expended materials could be ingested by marine invertebrates in all large marine ecosystems and open ocean areas. Ingestion could occur at the surface, in the water column, or on the seafloor, 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 feed at or near the water surface, while materials that sink to the seafloor present a higher risk to both filter-feeding sessile and bottom-feeding animals. Marine invertebrates are universally present in the water and the seafloor, but the majority of individuals are smaller than a few millimeters (e.g., zooplankton, most roundworms, and most arthropods). Most military expended materials and fragments of military expended materials are too large to be ingested by marine invertebrates. The potential for marine invertebrates to encounter fragments of ingestible size increases as the military expended materials degrades into smaller fragments.

If expended material is ingested by marine invertebrates, the primary risk is from a blocked 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 (see Section 3.8.3.6, Secondary Stressors, for more information on the chemical properties of these materials).

The most abundant military expended material of ingestible size is chaff. The materials in chaff are generally nontoxic in the marine environment except in quantities substantially larger than those any marine invertebrate could reasonably be exposed to from normal usage. Fibers are composed of an aluminum alloy coating on glass fibers of silicon dioxide. Chaff is similar in form to fine human hair, and somewhat analogous to the spicules of sponges or the siliceous cases of diatoms (Spargo 1999). Many invertebrates ingest sponges, including the spicules, without suffering harm (Spargo 1999). Marine invertebrates may occasionally encounter chaff fibers in the marine environment and may 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 training and testing (Arfsten et al. 2002; Spargo 1999). Studies were conducted to determine likely effects on marine invertebrates from ingesting chaff involving a laboratory investigation of crabs that were fed radiofrequency chaff. Blue crabs were force-fed a chaff-and-food mixture daily for a few weeks at concentrations 10 to 100 times predicted real-world exposure levels without a notable increase in mortality (Arfsten et al. 2002).

As described in Section 3.8.2 (Affected Environment), tens of thousands of marine invertebrate species inhabit the Study Area. There is little literature about the effects of debris ingestion on marine invertebrates; consequently, there is little basis for an evidence-based assessment of risks. It is not feasible to speculate on which invertebrates in which locations might ingest specific types of military expended materials. However, invertebrates that actively forage (e.g., worms, octopus, shrimp, and sea cucumbers) are at much greater risk of ingesting military expended materials than invertebrates that filter-feed (e.g., sponges, corals, oysters, and barnacles). Though ingestion is possible in some circumstances, based on the little scientific information available, it seems that negative impacts on individuals are unlikely and impacts on populations would be inconsequential and not detectable. Adverse consequences of marine invertebrates ingesting military expended materials are possible but not probable.

3.8.3.5.1.1 No Action Alternative

Training Activities

Under the No Action Alternative, a variety of potentially ingestible military expended materials (i.e., chaff) would be released to the marine environment by Navy training activities (Table 2.8-1). Ingestion is not likely in the majority of cases because most military expended materials are too large to be ingested by most marine invertebrates. Though ingestion is possible in some circumstances, based on the little scientific information available, it seems that negative impacts on individuals are unlikely and the potential for impacts on populations would be inconsequential and not detectable. Marine invertebrates may occasionally encounter chaff fibers in the marine environment and may 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 training and testing (Arfsten et al. 2002; Spargo 1999). Adverse consequences of marine invertebrates ingesting military expended materials are possible but not probable. The fraction of military expended materials of ingestible size, or that become ingestible after degradation, is unlikely to impact individuals.

Pursuant to the ESA, the use of military expended materials of ingestible size during training activities as described under the No Action Alternative would have no effect on ESA-listed coral species.

Testing Activities

Under the No Action Alternative, no testing activities that would create ingestion stressors are conducted in the Study Area.

3.8.3.5.1.2 Alternative 1

Training Activities

Under Alternative 1, a variety of potentially ingestible military expended materials would be released to the marine environment by Navy training activities. As with the No Action Alternative, ingestion is not likely because most military expended materials are too large to be ingested by most marine invertebrates. The fraction of military expended materials that are of ingestible size, or that become ingestible after degradation, may impact individual marine invertebrates, but are unlikely to have impacts on populations or sub-populations.

Under Alternative 1, the expended chaff would increase to 25,840 canisters per year in areas greater than 12 nm from shore within the Study Area compared with the No Action Alternative of 5,830 (Table 3.0-26). Marine invertebrates may occasionally encounter chaff fibers in the marine environment and may 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 training and testing (Arfsten et al. 2002, Spargo 1999). Adverse consequences of marine invertebrates ingesting military expended materials are possible but not probable.

Pursuant to the ESA, the use of military expended materials of ingestible size during training activities as described under Alternative 1 would have no effect on ESA-listed coral species.

Testing Activities

Under Alternative 1, a variety of potentially ingestible military expended materials would be released to the marine environment by Navy testing activities. Six hundred chaff canisters and 300 flares would be released during testing activities under Alternative 1. Ingestion is not likely in the majority of cases because most military expended materials are too large to be ingested by most marine invertebrates. The fractions of military expended materials that are of ingestible size, or become ingestible after degradation, are unlikely to impact individuals. Marine invertebrates may occasionally encounter chaff fibers in the marine environment and may 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 training and testing (Arfsten et al. 2002, Spargo 1999). Adverse consequences of marine invertebrates ingesting military expended materials are possible but not probable.

Pursuant to the ESA, the use of military expended materials of ingestible size during testing activities as described under Alternative 1 would have no effect on ESA-listed coral species.

3.8.3.5.1.3 Alternative 2

Training Activities

Under Alternative 2, the expended chaff would increase to 28,512 canisters per year in areas greater than 12 nm from shore within the Study Area compared with the No Action Alternative of 5,836 (Table 3.0-26). Though the number of canisters increases, it remains that chaff poses little environmental risk to marine organisms at concentrations that could reasonably occur from military training and testing (Arfsten et al. 2002, Spargo 1999). Adverse consequences of marine invertebrates ingesting military expended materials are possible but not probable.

Pursuant to the ESA, the use of military expended materials of ingestible size during training activities as described under Alternative 2 would have no effect on ESA-listed coral species.

Testing Activities

Under Alternative 2, a variety of potentially ingestible military expended materials would be released to the marine environment by Navy testing activities. Six hundred sixty chaff canisters and 330 flares would be released during testing activities under Alternative 2. Ingestion is not likely in the majority of cases because most military expended materials are too large to be ingested by most marine invertebrates. The fractions of military expended materials that are of ingestible size, or become ingestible after degradation, are unlikely to impact individuals. Marine invertebrates may occasionally encounter chaff fibers in the marine environment and may 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 training and testing (Arfsten et al. 2002, Spargo 1999). Adverse consequences of marine invertebrates ingesting military expended materials are possible but not probable.

Pursuant to the ESA, the use of military expended materials of ingestible size during testing activities as described under Alternative 2 would have no effect on ESA-listed coral species.

3.8.3.5.1.4 Substressor Impact on Sedentary Invertebrate Beds and Reefs as Essential Fish Habitat (Preferred Alternative)

Pursuant to the EFH requirements of the Magnuson-Stevens Fishery Conservation and Management Act and implementing regulations, the use of potentially ingestible military expended materials during training and testing activities could have an adverse effect on sedentary invertebrate beds or reefs that constitute EFH or Habitat Areas of Particular Concern. The EFHA states that the impact to sedentary invertebrate beds (e.g., amphipod tubes, bryozoans) may be minimal and long term.

3.8.3.5.2 Summary of Ingestion Impacts

Most military expended materials and fragments of military expended materials are too large to be ingested by marine invertebrates. The potential for marine invertebrates to encounter fragments of ingestible size increases as the military expended materials degrade into smaller fragments. The fractions of military expended materials of ingestible size, or that become ingestible after degradation, may impact individual marine invertebrates, but are unlikely to impact populations.

3.8.3.6 Secondary Stressors

This section analyzes potential impacts on marine invertebrates exposed to stressors indirectly through sediments and water quality. These two ecosystem constituents, sediment and water, are also primary constituents of marine invertebrate habitat and clear distinctions between indirect impacts and habitat impacts are difficult to maintain. For this analysis, indirect impacts on marine invertebrates via sediment or water that do not require trophic transfers (e.g., bioaccumulation) to be observed are considered here. The terms “indirect” and “secondary” do not imply reduced severity of environmental consequences, but instead describe *how* the impact may occur in an organism or its ecosystem.

Stressors from Navy training and testing activities could pose secondary or indirect impacts on marine invertebrates via habitat, sediment, or water quality. Components of these stressors that could pose indirect impacts include (1) explosives and byproducts; (2) metals; (3) chemicals; and (4) other materials such as targets, chaff, and plastics.

3.8.3.6.1 Explosives and Explosive Byproducts

High-order explosives consume most of the explosive material, creating typical combustion products. In the case of Royal Demolition Explosive, 98 percent of the combustion products are common seawater constituents and the remainder is rapidly diluted. Explosive byproducts from high order detonations present no indirect impacts to marine invertebrates through sediment or water. Low-order detonations and unexploded ordnance present an elevated likelihood of effects on marine invertebrates, and the potential impacts of these on marine invertebrates will be analyzed. Explosive material not completely consumed during a detonation from ordnance disposal and mine clearance training are collected after training is complete; therefore, potential impacts are assumed to be inconsequential and not detectable for these training and testing activities. Marine invertebrates may be exposed by contact with the explosive, contact with explosive byproducts within the sediments or water, and ingestion of chemical constituents in sediments. Most marine invertebrates are very small relative to ordnance or fragments, and direct ingestion of unexploded ordnance is unlikely.

Indirect impacts of explosives and unexploded ordnance on marine invertebrates via sediment are possible near the ordnance. Degradation of explosives proceeds via several pathways as discussed in Section 3.1 (Sediments and Water Quality). Degradation products of Royal Demolition Explosive are not toxic to marine organisms at realistic exposure levels (Rosen and Lotufo 2010). Trinitrotoluene and its degradation products impact developmental processes in marine invertebrates and are acutely toxic to adults at concentrations similar to real-world exposures (Rosen and Lotufo 2007b, 2010). The relatively low solubility of most explosives and their degradation products indicate that concentrations of these byproducts in the marine environment are relatively low and readily diluted. Furthermore, while explosives and their degradation products were detectable in marine sediment approximately 6–12 inches (15–30 centimeters) away from degrading ordnance, the concentrations of these compounds were not statistically distinguishable from background beyond 3 and 6 ft. (1 and 1.8 m) from the degrading ordnance (Section 3.1.3.1, Explosives and Explosive Byproducts). Taken together, marine invertebrates, eggs, and larvae probably would be adversely impacted by the indirect effects of degrading explosives within a very small radius of the explosive (1 to 6 ft. [0.3 to 1.8 m]).

Indirect impacts of explosives and unexploded ordnance on marine invertebrates via water are likely to be inconsequential and not detectable for two reasons. First, most explosives and explosive degradation products have very low solubility in sea water (Section 3.1, Sediments and Water Quality). This means that dissolution occurs extremely slowly, and harmful concentrations of explosives and degradation are not likely to accumulate except within confined spaces. Second, a low concentration of byproducts, slowly delivered into the water column, is readily diluted to non-harmful concentrations. Filter feeders in the immediate vicinity of degrading explosives may be more susceptible to bioaccumulation of chemical byproducts. While marine invertebrates may be adversely impacted by the indirect effects of degrading explosives via water (Rosen and Lotufo 2007a, 2010), this is extremely unlikely in realistic scenarios.

Impacts on marine invertebrates, including zooplankton, eggs, and larvae, are likely within a very small radius of the ordnance (1 to 6 ft. [0.3 to 1.8 m]). These impacts may continue as the ordnance degrades over months to decades. Because most ordnance is deployed as projectiles, multiple unexploded or low-order detonations would accumulate on spatial scales of 1 to 6 ft. (0.3 to 1.8 m); therefore, potential impacts are likely to remain local and widely separated. Given these conditions, the possibility of population-level impacts on marine invertebrates is inconsequential. However, if the sites of the depositions are the same over time, this could alter the benthic composition, affect bioaccumulation, and impact local invertebrate communities.

Strike warfare activities such as bombing exercises (Land) and missile exercises involve the use of live munitions by aircrews that practice on ground targets on FDM. These warfare training activities occur on FDM and are limited to the designated impact zones along the central corridor of the island. Explosives that detonate on land would disturb nearby soils that could then be transported through natural processes such as erosion by wind or rain into surface drainage areas or nearshore waters. It should be noted that FDM is highly susceptible to natural causes of erosion, because the island is comprised of highly weathered limestone overlain by a thin layer of clay soil. Sediments entering the nearshore environment as a result of natural processes or explosion on land could cause temporary water quality impacts, some of which may be in foraging areas used by marine organisms. By limiting the location and extent of target areas, along with the types of ordnance allowed within specific impact areas, the Navy minimizes the potential for soil transport and, thus, water quality impacts.

Erosion as a result of training activities at FDM may contribute to deposition of soils into the nearshore areas of FDM, causing increased turbidity. Turbidity can impact corals and invertebrate communities on hardbottom areas by reducing the amount of light that reaches these organisms and by clogging siphons for filter-feeding organisms. Reef-building corals are sensitive to water clarity because they host symbiotic algae that require sunlight to live. Encrusting organisms residing on hardbottom can be impacted by persistent silting from increased turbidity. However, as listed in the High-Order Explosions at FDM and Explosive Byproducts subsection of Section 3.1.3.1.6.1 (No Action Alternative), the impacts of explosive byproducts on sediment and water quality would be indirect, short term, local, and negative. Explosive ordnance could loosen soil on FDM, and runoff from surface drainage areas containing soil and explosive byproducts could subsequently enter nearshore waters. However, chemical, physical, or biological changes in sediment or water quality would not be detectable. Therefore, impacts on marine invertebrates from erosion or sedimentation are not anticipated. Refer to Section 3.1.3.1.5.3 (Farallon de Medinilla Specific Impacts) for information on surveys of the nearshore waters around FDM which assess impacts to the nearshore environment.

3.8.3.6.2 Metals

Certain metals and metal-containing compounds are harmful to marine invertebrates at concentrations above background levels (e.g., cadmium, chromium, lead, mercury, zinc, copper, manganese, and many others) (Negri et al. 2002; Wang and Rainbow 2008). Metals are introduced into seawater and sediments as a result of training and testing activities involving vessel hulks, targets, ordnance, munitions, and other military expended materials (Section 3.1.3.2, Metals). Many metals bioaccumulate and some physiological impacts begin to occur only after several trophic transfers concentrate the toxic metals. Indirect impacts of metals on marine invertebrates via sediment and water involve concentrations several orders of magnitude lower than concentrations achieved via bioaccumulation. Marine invertebrates may be exposed by contact with the metal, contact with trace amounts in the sediments or water, and ingestion of sediments. Ingested metals are toxic at substantially lower effective concentrations than metals dissolved or suspended in the water. Most marine invertebrates are very small relative to Navy military expended materials, and direct ingestion of metals is unlikely.

Because metals often concentrate in sediments, potential adverse indirect impacts are much more likely via sediment than via water. Despite the acute toxicity of some metals (e.g., hexavalent chromium or tributyltin) (Negri et al. 2002) concentrations above safe limits are rarely encountered even in live-fire areas such as Vieques (which is not in the MITT Study Area) where deposition of metals from Navy activities is very high. Pait (2010) and others sampled in areas in which live ammunition and weapons were used. Other studies described in Section 3.1.3.2 (Metals) find no harmful concentrations of metals from deposition of military metals into the marine environment. Marine invertebrates, eggs, or larvae could be indirectly impacted by metals via sediment within a few inches of the object.

As described in Section 3.1.3.2 (Metals), bomb fragments and unexploded bombs on FDM could be a source of metal byproducts in terrestrial and marine sediments. The Navy has in place an Operational Range Clearance Plan for FDM that includes range clearance, inspection, certification, demilitarization, and recycling or disposal procedures. The plan requires range surfaces at FDM to be cleared of ordnance, inert ordnance debris, inert munitions, and other material greater than 2 ft. (0.6 m) in length or diameter that may potentially present an explosive hazard. Range clearance on FDM occurs every 2–4 years, which removes potential sources of chemical byproducts from terrestrial sediments, marine sediments, and nearshore waters.

Concentrations of metals in sea water are orders of magnitude lower than concentrations in marine sediments. Marine invertebrates probably would not be indirectly impacted by Navy-derived toxic metals via the water, in the absence of bioaccumulation. It is conceivable, though extremely unlikely, that marine invertebrates, eggs, or larvae could be indirectly impacted by metals via sediment within a few inches of the object, but these potential impacts would be localized and widely separated. Concentrations of metals in water are extremely unlikely to be high enough to cause injury or mortality to marine invertebrates; therefore, indirect impacts of metals via water are likely to be inconsequential and not detectable. Given these conditions, the possibility of population-level impacts on marine invertebrates is likely to be inconsequential and not detectable.

3.8.3.6.3 Chemicals

Several Navy training and testing activities introduce potentially harmful chemicals into the marine environment; principally, flares and propellants from rockets, missiles, and torpedoes. Properly functioning flares, missiles, rockets, and torpedoes combust most of their propellants, leaving benign or readily diluted soluble combustion byproducts (e.g., hydrogen cyanide). Operational failures allow propellants and their degradation products to be released into the marine environment. The greatest risk to marine invertebrates from flares, missiles, and rocket propellants is perchlorate, which is highly soluble in water, persists in the environment, and is known to impact metabolic processes in many plants and animals. Marine invertebrates may be exposed by direct contact with a chemical found in the sediments or water or through ingestion of sediments containing trace amounts of a chemical. For perchlorate, these pathways are limited given that rapid dilution within the water column would be expected and missile and rocket propellant is mostly, if not completely, expended before the munition enters the water. Additionally, perchlorate does not readily absorb into sediments. Doses large enough to have detectable impacts on invertebrates would not be expected. Therefore, missile and rocket fuel pose inconsequential risks of direct or indirect impacts on marine invertebrates.

The principal toxic components of torpedo fuel, propylene glycol dinitrate and nitrodiphenylamine, do readily adsorb into sediments, but have relatively low toxicity and are readily degraded by physical and biological processes (Section 3.1.3.3, Chemicals Other Than Explosives). It is possible that marine invertebrates, eggs, or larvae could be indirectly impacted by hydrogen cyanide produced by torpedo fuel combustion, but these impacts would diminish rapidly as the chemical becomes diluted below toxic levels. Individual marine invertebrates, including eggs and larvae, could be indirectly impacted by chemicals from propellants, fuels (e.g., hydrogen cyanide from torpedoes fuel), or other chemicals imbedded in sediments, if the organisms are located in close proximity to the chemical (i.e., within a few inches), but any potential effects would diminish rapidly with distance from the source and as the chemical degrades in the environment.

Concentrations of chemicals in sediment and water are not likely to cause injury or mortality to marine invertebrates; therefore, indirect impacts of chemicals via sediment and water are likely to be inconsequential and not detectable. Potential impacts of chemicals after bioaccumulation are discussed separately. Population-level impacts on marine invertebrates would be inconsequential and not detectable.

3.8.3.6.4 Other Materials

Military expended materials that are re-mobilized after their initial contact with the seafloor (e.g., by waves or currents) may continue to strike or abrade marine invertebrates. Secondary physical strike and disturbances are relatively unlikely because most expended materials are more dense than the surrounding sediments (i.e., metal), and are likely to remain in place as the surrounding sediment moves. The principal exception is likely to be decelerators/parachutes, which are moved easily relative to projectiles and fragments. Potential secondary physical strike and disturbance impacts may cease only: (1) when the military expended materials is too massive to be mobilized by typical oceanographic processes, (2) when the military expended material becomes encrusted by natural processes and incorporated into the seafloor, or (3) when the military expended materials becomes permanently buried. The fitness of individual organisms would be impacted directly or indirectly, but not to the extent that the viability of populations or species would be impacted.

All military expended material, including targets and vessel hulks used for Sinking Exercises that contain materials other than metals, explosives, or chemicals, is evaluated for potential indirect impacts on marine invertebrates via sediment and water. Principal components of these military expended materials include aluminized fiberglass (chaff); carbon or Kevlar fiber (missiles); and plastics (canisters, targets, sonobuoy components, decelerators/parachutes, etc.). Potential effects of these materials are discussed in Section 3.1.3.4 (Other Materials). Chaff has been extensively studied, and no indirect toxic effects are known to occur at realistic concentrations in the marine environment (Arfsten et al. 2002). Glass, carbon, and Kevlar fibers have no known potential toxic effects on marine invertebrates. Plastics contain chemicals which could indirectly affect marine invertebrates (Derraik 2002; Mato et al. 2001; Teuten et al. 2007). Marine invertebrates may be exposed by contact with the plastic, contact with residual plastic chemical byproducts in the sediment or water, or ingestion of sediments containing plastic byproducts. Most marine invertebrates are very small relative to Navy military expended materials or fragments of military expended materials, and direct ingestion of plastics is unlikely.

The only material that could impact marine invertebrates via sediment is plastics. Harmful chemicals in plastics interfere with metabolic and endocrine processes in many plants and animals (Derraik 2002). Potentially harmful chemicals in plastics are not readily adsorbed to marine sediments; instead, marine invertebrates are most at risk via ingestion or bioaccumulation (Section 3.8.3.5, Ingestion Stressors; this section; and Section 3.3, Marine Habitats). Because plastics retain many of their chemical properties as they are physically degraded into microplasticparticles (Singh and Sharma 2008), the exposure risks to marine invertebrates are dispersed over time. Marine invertebrates could be indirectly impacted by chemicals from plastics but, absent bioaccumulation, these impacts would be limited to direct contact with the material. Because of these conditions, population-level impacts on marine invertebrates attributable to Navy expended materials are likely to be inconsequential and not detectable.

Pursuant to the ESA, secondary stressors from training and testing activities under the No Action Alternative, Alternative 1, and Alternative 2 would have no effect on ESA-listed coral species.

3.8.3.6.5 Substressor Impact on Sedentary Invertebrate Beds and Reefs as Essential Fish Habitat (Preferred Alternative)

Pursuant to the EFH requirements of the Magnuson-Stevens Fishery Conservation and Management Act and implementing regulations, the use of metal, chemical, and other material byproducts, and secondary physical disturbances during training and testing activities, will have no adverse effect on sedentary invertebrate beds or reefs that constitute EFH or Habitat Areas of Particular Concern. The use of explosives, explosive byproducts, and unexploded ordnance during training and testing activities may have an adverse effect on sedentary invertebrate beds or reefs that constitute EFH or Habitat Areas of Particular Concern. The EFHA states that substressor impacts on invertebrate beds or reefs would be minimal and short-term within the Study Area.

3.8.4 Summary of Potential Impacts on Marine Invertebrates

3.8.4.1 Combined Impacts of All Stressors

This section evaluates the potential for combined impacts of all the stressors from the proposed action. The analysis and conclusions for the potential impacts from each of the individual stressors are discussed in the sections above. Stressors associated with Navy training and testing activities do not typically occur in isolation but rather occur in some combination. For example, mine neutralization activities include elements of acoustic, physical disturbance and strike, entanglement, ingestion, and secondary stressors that are all coincident in space and time. An analysis of the combined impacts of all stressors considers the potential consequences of aggregate exposure to all stressors and the repetitive or additive consequences of exposure over multiple years. This analysis makes the reasonable assumption that the majority of exposures to stressors are non-lethal, and instead focuses on consequences potentially impacting the organism's fitness (e.g., physiology, behavior, reproductive potential).

It is unlikely that mobile or migratory marine invertebrates that occur within the water column would be exposed to multiple activities during their lifespan because they are relatively short-lived, and most Navy training and testing activities impact small widely-dispersed areas. It is much more likely that stationary organisms or those that only move over a small range (e.g., corals, worms, and sea urchins) would be exposed to multiple activities because many Navy activities recur in the same location (e.g., gunnery and mine warfare).

Multiple stressors can co-occur with marine invertebrates in two general ways. The first would be if a marine invertebrate were exposed to multiple sources of stress from a single activity. The second is exposure to a combination of stressors over the course of the organism's life. Both general scenarios are more likely to occur where training and testing activities are concentrated. The key difference between the two scenarios is the amount of time between exposures to stressors. Time is an important factor because some stressors develop over a long period while others occur and pass quickly (e.g., dissolution of secondary stressors into the sediment versus physical disturbance). Similarly, time is an important factor for the organism because subsequent disturbances or injuries often increase the time needed for the organism to recover to baseline behavior/physiology, extending the time that the organism's fitness is impacted.

Marine invertebrates are susceptible to multiple stressors, and susceptibilities of many species are enhanced by additive or synergistic effects of multiple stressors. The global decline of corals, for example, is driven primarily by synergistic impacts of pollution, ecological consequences of overfishing, and climate change. As discussed in the analyses above, marine invertebrates are not particularly susceptible to energy, entanglement, or ingestion stressors resulting from Navy activities; therefore, the opportunity for Navy stressors to result in additive or synergistic consequences is most likely limited to acoustic, physical strike and disturbance, and secondary stressors.

Despite uncertainty in the nature of consequences resulting from combined impacts, the location of potential combined impacts can be predicted with more certainty because combinations are much more likely in locations that training and testing activities are concentrated. However, analyses of the nature of potential consequences of combined impacts of all stressors on marine invertebrates remain largely qualitative and speculative. Where multiple stressors coincide with marine invertebrates, the likelihood of a negative consequence is elevated but it is not feasible to predict the nature of the consequence or its likelihood because not enough is known about potential additive or synergistic interactions. Even for shallow-water coral reefs, an exceptionally well-studied resource, predictions of the consequences of multiple stressors are semi-quantitative and generalized predictions remain qualitative (Hughes and Connell 1999; Jackson 2008; Norström et al. 2009). It is also possible that Navy stressors will combine with non-Navy stressors, and this is qualitatively discussed in Chapter 4 (Cumulative Impacts).

3.8.4.2 Endangered Species Act Determinations

Table 3.8-4 summarizes the Navy's determination of effect on ESA-listed marine invertebrates for each stressor based on the previous analysis sections. Accordingly, the Navy is including the 4 listed species of corals in the Section 7 ESA consultation with NMFS. No other ESA-listed invertebrate species occurs within the Study Area.

3.8.4.3 Essential Fish Habitat Determinations

Pursuant to the EFH requirements of the Magnuson-Stevens Fishery Conservation and Management Act and implementing regulations, the use of sonar and other acoustic sources; vessel noise; swimmer defense airguns; weapons firing noise; vessel movement; in-water devices; and metal, chemical, or other material byproducts will have no adverse effect on sedentary invertebrate beds or reefs that constitute EFH or Habitat Areas of Particular Concern. The use of explosives, electromagnetic sources, military expended materials, seafloor devices, and explosives and explosive byproducts may have an adverse effect on EFH by reducing the quality and quantity of sedentary invertebrate beds or reefs that constitute EFH or Habitat Areas of Particular Concern. The EFHA states that individual stressor impacts were all either no effect, or minimal and ranged in duration from temporary to permanent, depending on the stressor.

Table 3.8-4: Summary of Endangered Species Act Determinations for Marine Invertebrates for the Preferred Alternative (Alternative 1)

Stressor		ESA-listed Corals
Acoustic Stressors		
Sonar and Other Active Acoustic Sources	Training Activities	May affect
	Testing Activities	May affect
Explosives and Other Impulsive Acoustic Sources	Training Activities	May affect
	Testing Activities	May affect
Energy Stressors		
Electromagnetic Devices	Training Activities	No Effect
	Testing Activities	No Effect
Physical Disturbance and Strike Stressors		
Vessels and In-water Devices	Training Activities	May affect
	Testing Activities	May affect
Military Expended Materials	Training Activities	May affect
	Testing Activities	May affect
Seafloor devices	Training Activities	No Effect
	Testing Activities	No Effect
Entanglement Stressors		
Fiber Optic Cables and Guidance Wires	Training Activities	No Effect
	Testing Activities	No Effect
Decelerators/parachutes	Training Activities	No Effect
	Testing Activities	No Effect
Ingestion Stressors		
Military Expended Materials	Training Activities	No Effect
	Testing Activities	No Effect
Secondary Stressors		
Explosives, Explosive Byproducts, Unexploded Ordnance, Metals, Chemicals, and Other Materials	Training Activities	No Effect
	Testing Activities	No Effect

Note: ESA = Endangered Species Act

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