3.6 Fish

3.6 FISH

3.6.1 Affected Environment

For purposes of this Environmental Impact Statement/Overseas Environmental Impact Statement (EIS/OEIS), the Region of Influence (ROI) for fish is the Gulf of Alaska (GOA) Temporary Maritime Activities Area (TMAA). The TMAA is more than 12 nautical miles (nm) (22 kilometers [km]) from the closest point of land and is therefore outside of United States (U.S.) territorial seas. Thus, this section provides an overview of the species, distribution, and occurrence of fishes that are either resident or migratory through the GOA TMAA. A brief discussion of Essential Fish Habitat (EFH) is provided in Section 3.6.1.2 of this EIS/OEIS and a brief discussion of federally listed threatened and endangered fish species protected under the Endangered Species Act (ESA) in the TMAA is provided in Section 3.6.1.3.

In the GOA, the majority of the fishery resources are found along the broad continental shelf ecosystem (Richardson and Erickson 2005). Important marine species include salmonids (Chinook, coho, chum, pink and sockeye salmon, and steelhead), Pacific halibut, shelf and slope groundfish (walleye pollock, Pacific, sablefish, rockfishes, rex sole, Dover sole, arrowtooth flounder), dungeness crab, and scallops (U.S. Department of Commerce, National Oceanic and Atmospheric Administration [USDC, NOAA] 2005; Richardson and Erickson 2005). The Pacific high seas salmon are arguably the most important living marine resource within the GOA. Currently the GOA supports habitats of “endangered” and “threatened” populations of high seas salmon (Chinook, coho, chum, and sockeye salmon, and steelhead) (Section 3.6.1.3) (NMFS 2005b, 2005c).

The TMAA falls within the Alaska Current (AC) and the Alaska Coastal Current (ACC) systems. Both currents flow in a northerly direction off southeastern Alaska and then turn southwestward along the Alaska coast. Beyond Kodiak Island, the AC intensifies and becomes the Alaskan Stream as it flows along Alaskan Peninsula and the Aleutian Archipelago (Reed and Schumacher 1986). The AC system is rich in microscopic organisms (i.e., large-celled diatoms, small cyanobacteria, microflagellates, micro-/meso-zooplankton) which form the base of the food chain in the GOA. Grazers like forage species and small pelagic fish depend on this planktonic food supply, and in turn are forage for larger species, such as highly migratory species (e.g., high seas salmon) (Parsons 1986).

The TMAA and vicinity is a highly productive region for various marine fish and shellfish populations and supports some of the most productive fisheries in the United States. (Lanksbury et al. 2005). It is also an important spawning area for many fishes, supporting a diverse array of larval fish species influenced by bathymetric features (i.e., shelf, slope, etc.) in the spring and bathymetry/circulation features in the autumn (Doyle et al. 2002, Matarese et al. 2003, Doyle et al. 2005, Lanksbury et al. 2005). At least 383 species belonging to 84 families of marine and anadromous fishes have been reported from the predominant ecosystems found in the GOA TMAA: nearshore, continental shelf/slope, and offshore areas (Mecklenburg et al. 2002). Bony fishes (e.g., sculpins, snailfish, rockfish, and flatfish) dominate the number of species in the GOA with less than 10 percent of species being cartilaginous fishes (e.g., sharks, skates) (Mundy and Hollowed 2005). Shellfish (arthropods [e.g., crabs/shrimps] and mollusks (e.g., scallops, squids, and octopuses]) along with other benthic invertebrates comprise the bottom assemblage on the shelf/slope and nearshore areas in number of species and biomass (Feder and Jewett 1986; Outer Continental Shelf Environmental Assessment program [OCSEAP] 1986).

The fish fauna of the GOA consists of a mix of temperate and subarctic species, resulting in a large gradient in species composition along the shelf from the eastern to the western GOA (Hart 1973). Nearshore areas (e.g., Kodiak Island, lower Cook Inlet, and Prince William Sound) consisting of habitats such as rocky/kelp, epipelagic, intertidal beaches, subtidal shelves, and deeper bottom of bays serve as important spawning and nursery grounds for juveniles of numerous demersal and pelagic species (Rogers 1986, Rogers et al. 1986). These species include high seas salmon, walleye pollock, Pacific cod, crab, flatfish, and various forage species (Mueter 2004). The life history of many of these species is closely tied to the cyclonic boundary currents (e.g., subarctic), which transport eggs and larvae, and serve as important migratory pathways for juvenile salmon (Beamish et al. 2005).

Offshore areas are dominated by large epipelagic species that are capable of moving independently of currents (i.e., nekton), such as high seas salmon throughout the year with Pacific pomfret (*Brama japonica*), Pacific saury (*Cololabis saira*), and albacore tuna being common in the summer. These offshore areas in the GOA provide the principal feeding habitat for many species, particularly high seas salmon (Brodeur et al. 1999). All of these various species display a strong latitudinal gradient with their distribution correlating with sea surface temperature (Mueter 2004).

3.6.1.1 Existing Conditions

The following discussion provides an overview of the predominant fish species and habitat types known to occur in the TMAA. Two fish categories are described: salmonids and groundfish. As discussed in Section 3.5, Marine Plants and Invertebrates, the TMAA is over 12 nm (22.2 km) offshore and includes primarily offshore open ocean habitats including pelagic, continental shelf, slope, and abyssal plain regions, which are influenced by both the ACC and the Alaska Gyre.

Salmonids

There are six dominant species of salmon that occur in the GOA and have the potential of occurring in the TMAA: Chinook (*O. tshawytscha*), coho (*O. kisutch*), chum (*O. keta*), pink (*O. gorbuscha*), sockeye (*O. nerka*), and steelhead (*O. mykiss*). Salmonids found in the GOA are anadromous fish species that spend at least part of their adult life in the ocean but return to freshwater environments to spawn.

Pacific salmon (genus *Oncorhynchus*) range from San Francisco Bay, California, northward around the Pacific Rim through Alaska and southward along the coasts of Russia, Japan, and Korea (Myers et al. 1998). There are seven species of Pacific salmon; two species, masu (*Oncorhynchus masou*) and amago (*O. rhodurus*) only occur in Asia, and five species, Chinook, coho, chum, pink, and sockeye reproduce in North America and Asia (Groot and Margolis 1991; DFO 2002; USDC, NOAA 2005).

Until 1988, steelhead (the anadromous form of rainbow trout) was classified in the genus *Salmo* along with Atlantic salmon, brown trout, and several western trout species. With additional osteology and biochemistry data, biologists have now reclassified steelhead as members of the genus *Oncorhynchus*. The reason for this is that new information suggested that steelhead are more closely related to Pacific salmon than to brown trout and Atlantic salmon. As such, the American Fisheries Society - American Society of Ichthyologists Committee on Names of Fishes voted unanimously to accept *Oncorhynchus* as the proper generic name. For full scientific details, see Smith and Stearley 1989. As such, the scientific name of steelhead was changed from *Salmo gairdneri* to *Oncorhynchus mykiss*.

In general, the life history of Pacific salmon and steelhead includes incubation, hatching and emergence in freshwater, migration to the ocean, and subsequent initiation of maturation and return to freshwater for completion of maturation and spawning (Eggers 2004). Salmon are anadromous, meaning that they migrate up rivers and streams from the sea to spawn in freshwater. Pacific salmon spawn in gravel beds in rivers, streams and along lake-shores where females lay their eggs in nests or “redd” (Groot and Margolis 1991, Eggers 2004). Depending on the species, they spend between 1 to 7 years at sea, with most making extensive and complicated migrations (Quinn 2005). Generally, Pacific salmon return to their natal rivers to spawn and, with few exceptions, die soon after (Quinn 2005). The death of these salmon returns much-needed nutrients from the ocean to the otherwise nutrient-poor streams (Groot and Margolis 1991). Anadromy and the strong fidelity of homing to their natal streams have resulted in the development of many reproductively isolated subpopulations (little inbreeding occurs between salmon from one river and another) referred to as stocks (Quinn 2005). These subpopulations are exposed to different physical and biotic factors such as temperature, flow, gravel size, predators, prey, competitors, and pathogens (Quinn 2005). These variations between streams have led to the evolution of specializations to help the salmon survive in their home rivers (PFMC 2000). These distinct habitat dynamics require these subpopulations be managed individually rather than as one homogenous species (Duffy et al. 2005).

Groundfish Species

Groundfish species (i.e., flatfish, rockfish, roundfish, skates, sharks and chimeras) support important commercial and recreational fisheries. A brief summary of the fisheries management is provided below. Many species of groundfish have EFH in the TMAA, and are discussed in more detail in Section 3.6.1.2

Groundfish range throughout the EEZ and occupy diverse habitats at all stages in their life histories. Some species are broadly dispersed during specific life stages, especially those with pelagic eggs and larvae. The distribution of other species and/or life stages may be relatively limited, as with adults of many nearshore rockfish which show strong affinities to a particular location or substrate type.

The continental shelf/slope supports a large biomass of groundfishes, particularly the wide shelf and banks around Kodiak Island, northwest of the GOA TMAA (Mueter 2004). Typically, the groundfish community in the GOA exhibits strong-depth gradient in species composition and diversity (Mueter and Norcross 2002) found in many other demersal fish communities inhabiting shelf and upper slope regions (Colvocoresses and Musick 1984, Jay 1996, Mahon et al. 1998). Information is lacking about demersal species on the deeper parts of the slope, continental rise, in the deep central basin, and on the numerous seamounts (Mueter 2004). Faunal assemblages collected from GOA seamounts, south of the TMAA, were dominated by giant (*Albatrossia pectoralis*) and Pacific (*Coryphaenoides acrolepis*) grenadiers, rockfish (*Sebastes* spp. and *Sebastolobus* sp.), and sablefish (Hoff and Stevens 2005) and may be representative of other seamounts in the GOA (Maloney 2004, Morato and Pauly 2004).

Flatfish are represented by halibut, flounders, soles, turbots, and plaice (Mecklenburg et al. 2002). Flatfish are demersal, meaning they live on the seafloor. Most marine flatfishes have planktonic egg and larval stages and they drift with currents for periods of weeks to months; therefore, larvae depend on features of currents to either retain them or transport them to suitable nursery areas. Most species change their diet from zooplankton to benthic animals as they settle on the bottom. Flatfishes often have highly specific habitat requirements for their juvenile and adult stages (Gibson 1994). In regions characterized by a landscape of suitable habitat, fragmented by barriers of unsuitable habitat such as deep sea valleys and canyons, colonization and recruitment are likely to depend on larval drift rather than movement of juveniles or adults across such barriers (Bailey et al. 2003). In the GOA, the landscape of suitable juvenile habitat is fragmented by troughs, sea valleys, and rocky areas. Delivery of larvae into suitable nursery areas is unpredictable due to the highly variable Alaska Coastal Current. In general, flatfish do not exhibit large-scale migration, but most of them move to shallower waters in spring and return to deeper waters in autumn.

Halibut exhibit similar life history traits. Previous research suggests that important settlement and nursery grounds for the eastern Pacific halibut population are located primarily in shallow coastal waters, extending from Dixon Entrance in British Columbia to the Bristol Bay region of the southeastern Bering Sea. Following approximately two years of residence on the nursery grounds, juveniles are believed to migrate in a southeasterly direction, arriving on the fishing grounds as four- or five-year-olds. Present day halibut fisheries harvest fish throughout the continental shelf of Canada and the United States on the species' summer feeding grounds. During the winter months, most of these fish depart the relatively shallow waters of the shelf to aggregate and spawn in deeper waters along the shelf-edge, at spawning grounds that stretch from at least the Queen Charlotte Islands through the Bering Sea and westward; however, rather than simply moving offshore from the locations at which they feed, conventional tagging data suggest that many halibut may move considerable distances along the shore during the seasonal migration. Halibut appear to aggregate in northern GOA in the winter and may emigrate (arrive) from British Columbia and areas south of the Alaska Peninsula.

Rockfish of the Family Scorpaenidae inhabit rocky areas in shallow to moderately deep water or occur farther offshore on silty and sandy, soft bottoms in the marine waters of the TMAA and are represented by the genera *Sebastes* and *Sebastolobus* (Mecklenburg et al. 2002). Approximately 32 of the 36 species of *Sebastes* and two of the three species *Sebastolobus* species have been documented in the TMAA. Rockfish diversity is highest in southern southeast Alaska with the number of species declining markedly west of the central GOA (Enticknap and Sheard 2005). The rockfishes have been divided into three assemblages for management purposes based on species habitat and distribution, as well as commercial composition data: slope, demersal shelf, and pelagic shelf, whereas the thornyheads are managed independently (O'Connell et al. 2003; USDC, NOAA 2005). Rockfish are long-lived and sexual maturity is attained between 5 and 20 years of age. Spawning for most species generally takes place in the early spring (April) or late fall. Once hatched (late winter to mid-summer) the juvenile larvae form part of the pelagic community for up to 3 years and use nearshore habitats. Due to their long lives and late sexual maturity, rockfish are extremely susceptible to over harvest and stock depletion.

Species of sharks and skates that are known to occur in the GOA include salmon shark (*Lamna ditropis*), spiny dogfish (*Squalus acanthias*), big skate (*Raja binoculata*), and longnose skate (*R. rhina*). Sharks and skates form part of the benthic and near-bottom fish communities and are not classified as food fish. These species are often caught as bycatch in groundfish fisheries.

Summary of Fisheries Management

The oldest fisheries in the GOA are the native subsistence fisheries for Pacific halibut, cod, herring, and other species. Catches were traded or sold to the Russians and later to the Americans after the purchase of Alaska by the United States in 1867. Groundfish and herring are still important sources of food to many groups of Alaskan natives, although these subsistence harvests are now dwarfed by commercial operations (North Pacific Fishery Management Council [NPFMC] 2009).

The commercial fishery for halibut began in coastal waters off Washington and British Columbia and expanded from there into the GOA after World War I. Both U.S. and Canadian nationals were involved in the fisheries, and in 1923 the United States and Canada ratified a halibut conservation treaty to regulate the fishery and to conduct research. The convention established the International Fisheries Commission, which was changed to the International Pacific Halibut Commission in 1953. Because of a combination of overfishing and environmental factors, the abundance of halibut declined and a new convention was signed in 1930 to broaden the Commission's regulatory powers for the rebuilding of the halibut stocks. Under scientific management, the halibut stocks were gradually rebuilt (NPFMC 2009). The potential adverse impact on halibut from the commercial groundfish fisheries is such that it must be taken into account in the management of the groundfish fishery.

Commercial groundfish are managed through the NPFMC’s GOA Groundfish Fishery Management Plans, but the International Pacific Halibut Commission is responsible for management of the North American Pacific halibut fishery, under the authority of the Convention for the Preservation of the Halibut Fishery of the North Pacific Ocean and the Bering Sea. Within the Groundfish Fishery Management Plan, the flatfish assemblage has been divided into several categories for management purposes. Catch limits for flatfish are specified separately for the deep water flatfish complex (Dover sole, Greenland turbot, and deep-sea sole), rex sole, the shallow water flatfish complex (rock sole, yellowfin sole, Alaska plaice, and other flatfish), flathead sole, and arrowtooth flounder.

The eastern north Pacific halibut resource is presently managed under the assumption that a single panmictic population (i.e., a fully mixed population in which members from all geographic regions regularly interbreed) exists from California through the eastern Bering Sea (International Pacific Halibut Commission [IPHC] 2010). This assumption rests largely upon studies that indicate northwesterly larval drift throughout the GOA and into the Bering Sea, balanced by southeasterly migration of juveniles and adults over broad geographic expanses. In addition, limited genetic studies have failed to demonstrate significant difference between northern and southern stock components. Thus, Pacific halibut in the eastern Pacific Ocean are treated as a single unit stock with regard to reproduction and recruitment, and managed as a series of regulatory areas with respect to harvest guidelines (IPHC 2010).

The IPHC regulatory or statistical areas are depicted in Figure 3.6-1. The boundaries of the TMAA overlap with five IPHC statistical areas: 230, 240, 250, 260, and 270. The overlap with statistical areas 230 and 270 is very small compared with a larger overlap in areas 240, 250, and 260. The halibut fishery is conducted in these areas between March through November (IPHC 2010). The majority of the fishery occurs over the shelf in waters 200 meters or less; however there have been reports of halibut caught in much deeper waters (up to 500 meters) during the summer months (Adams pers. comm. 2010). The Alaska Fisheries Science Center of NMFS conducts annual surveys in the GOA and has found that the frequency of occurrence of halibut in the summer occurs at depths between 100-150 meters and the frequency sharply falls off at 200 meters. For example, out of 3,004 individuals caught in waters up to 550 meters deep, 2,958 individuals were caught in depths less than 200 meters, 46 individuals caught between 200-550 meters, and of those 46 fish only 8 individuals were caught at depths between 400 to 500 meters (Von Szalay pers. comm. 2010).

The sablefish fishery began about 1906, and was relatively unimportant until about 1935 when the catch began to increase with effort continuing through 1945. Since 1946, the harvest has fluctuated and, following a period of stock decline, the fishery has now expanded to all areas of the GOA (NPFMC 2009).

Fish Habitat in the Gulf of Alaska TMAA

Habitat characteristics include geomorphic, physical, biological, and chemical parameters. Interactions between environmental parameters make up habitat and determine the biological niche of a species.

Habitat parameters affecting fish distribution throughout the TMAA include both physical (depth, substrate, temperature, salinity, and dissolved oxygen) and biological (competitors, predators, and facilitators) variables (NMFS-Northwest Region [NWR] 2005). Habitat types in the GOA can be separated into two zoogeographic provinces: coastal Aleutian (Aleutian Islands to Sitka, Alaska, Dixon Entrance, or Cape Flattery, Washington) and oceanic Subarctic (GOA to Latitude 43°N). These provinces can further be broken down into the following habitat types utilized by managed fishes within the GOA (Briggs 1974, Feder and Jewett 1986, O'Clair and Zimmerman 1986, Allen and Smith 1988, Malecha et al. 2005, Peterson 2005).

As discussed in Section 3.5, the TMAA is over 12 nm (22.2 km) offshore and does not include nearshore habitat, but primarily consists of offshore open ocean habitats including pelagic, continental shelf, slope, and abyssal plain regions, which are influenced by both the ACC and the Alaska Gyre. However, a brief description of nearshore habitats is provided since some fishes may utilize this habitat throughout their life cycle.

Nearshore Habitats

Embayments

Embayments include bays, fjords, and inlets influenced by both the ocean and river and serve as the transitional zone between fresh and saltwater. Major embayments found north and northwest of the TMAA include Prince William Sound, Resurrection Bay, and lower Cook Inlet.

Islands

Islands include areas separated from the mainland by straits (Kodiak Island by Shelikof Strait) or occurring at mouth of embayments (Montague Island – Prince William Sound or Barrens Island – lower Cook Inlet).

Nearshore Biogenic Habitats

Nearshore biogenic habitats include kelp, seagrass, and epifaunal invertebrates. The biological component (kelp, seagrass, or epifaunal invertebrates) associated with the habitat is generally the feature that makes that habitat suitable for a particular species or life stage (e.g., groundfish).

Nearshore Unconsolidated Bottom (silt, mud, gravel, or mixed)

Composed of small particles (gravel, sand, mud, silt, or mixtures of these particles), these areas contain little to no vegetation due to the lack of stable surfaces for attachment. Contains infaunal invertebrates (i.e., polychaetes, other worms, bivalves) and abundant transient consumers (e.g., fishes, crustaceans, shorebirds).

Nearshore Hardbottom

Nearshore hardbottom is composed of bedrock, boulders, cobble, or gravel/cobble. Nearshore hardbottom is one of the least abundant benthic habitats, but one of the most important for fishes, especially rockfish (e.g., *Sebastes* spp.), lingcod, and sculpins. Most Alaska Pacific herring stocks spawn in intertidal and shallow subtidal hardbottom.

Nearshore Water Column

The nearshore water column, or coastal epipelagic zone, includes egg, juvenile, and larval stages of groundfish commonly associated with macrophyte canopies or drift algae.

Offshore (Shelf and Slope Habitats)

Offshore Biogenic Habitats (corals, sponges, etc.)

Biogenic habitats include structure-forming invertebrates such as corals, basketstars, brittlestars, demosponges, gooseneck barnacles, sea anemones, sea lilies, sea urchins, sea whips, tube worms, and vase sponges.

Offshore Unconsolidated Bottom (silt, mud, sand, gravel, or mixed)

Unconsolidated bottom is composed of cobble, gravel, sand, or silt which contains little to no vegetation due to the lack of stable surfaces for attachment.

Offshore Hardbottom

The hardbottom is composed of bedrock, boulders, cobble, or gravel/cobble. Large, mobile, demersal fishes (e.g., rockfish, sablefish, Pacific hake, spotted ratfish) are typically associated with this habitat.

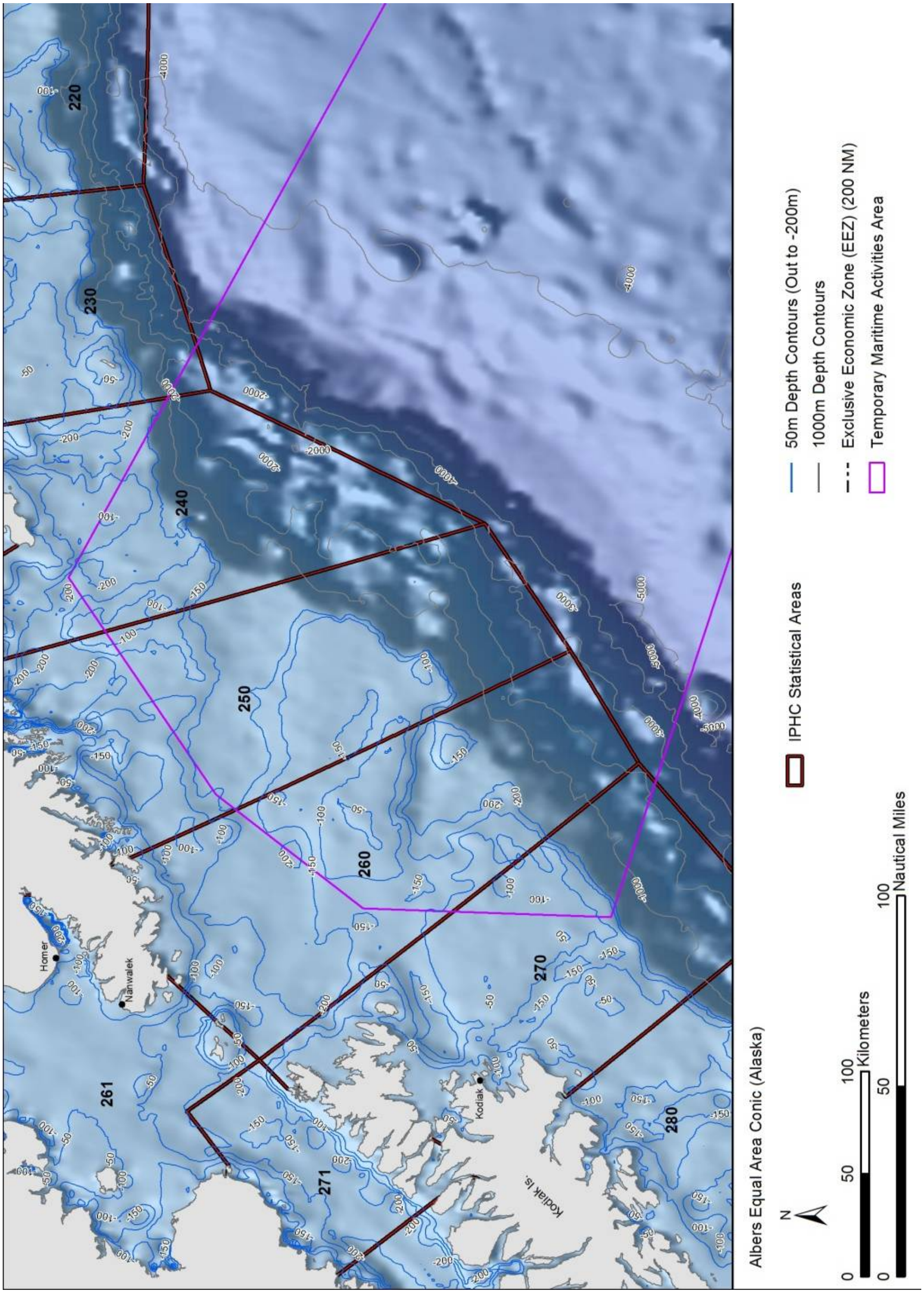

Figure 3.6-1: International Pacific Halibut Commission Statistical Areas

Offshore Artificial Structures

Artificial structures include artificial reefs utilized by rockfish. Artificial reefs are often composed of concrete, tires, or sunken ships; these features create habitat for sea life.

Offshore Water Column: Pelagic Zone

The pelagic zone is home to the highly migratory species (e.g., high seas salmon), other relatively large pelagics, and early life stages of groundfish inhabiting the epipelagic/mesopelagic area or that are in association with fronts, current systems, and macrophyte canopies or drift algae associated with the TMAA.

3.6.1.2 Essential Fish Habitat

The Magnuson-Stevens Fishery Conservation and Management Act (MSFCMA) (16 United States Code [U.S.C.] §1801 et seq.), as amended by the Sustainable Fisheries Act (SFA), mandates identification and conservation of EFH. The MSFCMA defines EFH as those waters and substrates necessary (required to support a sustainable fishery and the managed species) to fish for spawning, breeding, feeding, or growth to maturity (i.e., full life cycle). These waters include aquatic areas and their associated physical, chemical, and biological properties used by fish, and may include areas historically used by fish. Substrate types include sediment, hard bottom, structures underlying the waters, and associated biological communities. Federal agencies are required to consult with NMFS and to prepare an EFH Assessment if potential adverse effects on EFH are anticipated from their activities. A detailed EFH Assessment has been prepared for the TMAA.

The NMFS and regional Fishery Management Councils (FMCs) develop EFH descriptions for federally managed fish species and include them in their respective Fishery Management Plans (FMPs). The FMPs identify and describe EFH, describe the EFH impacts (fishing and nonfishing), and suggest measures to conserve and enhance the EFH. The NPFMC developed FMPs for all fisheries occurring within the boundary of the TMAA. A description of designated EFH for the life stage that occurs within the TMAA is presented in Tables 3.6-1 and 3.6-2. The GOA is defined in the FMP as the U.S. EEZ of the North Pacific Ocean, exclusive of the Bering Sea, between the eastern Aleutian Islands at 170°W longitude and Dixon Entrance at 132°40’W longitude and includes the Western, Central, and Eastern regulatory areas (USDC, NOAA 2005).

Table 3.6-1: The Fish and Invertebrate Species with EFH Designated in the Gulf of Alaska TMAA

Fishery Management Plan	Species	Eggs	Larvae	Early Juvenile	Late Juvenile	Adult
Scallop	Weathervane scallop				X	X
Groundfish	Arrowtooth flounder		X		X	X
	Atka mackerel		X			
	Dover sole	X	X		X	X
	Dusky rockfish		X			X
	Flathead sole	X	X		X	X
	Northern rockfish		X			X
	Pacific cod	X	X		X	X
	Pacific ocean perch		X		X	X
	Rex sole	X	X		X	X
	Rock sole		X		X	X
	Sablefish	X	X		X	X
	Sculpins				X	X

Table 3.6-1: The Fish and Invertebrate Species with EFH Designated in the Gulf of Alaska TMAA (continued)

Fishery Management Plan	Species	Eggs	Larvae	Early Juvenile	Late Juvenile	Adult
Groundfish (continued)	Shortraker / rougheye rockfish		X			X
	Skates					X
	Squid				X	X
	Thornyhead rockfish		X		X	X
	Walleye Pollock	X	X		X	X
	Yelloweye rockfish		X		X	X

Table 3.6-2: Salmon Species with EFH Designated in the Gulf of Alaska TMAA

Fishery Management Plan	Species	Freshwater Eggs	Freshwater Larvae/ Juveniles	Estuarine Juveniles	Marine Juveniles	Marine Immature/ Maturing Adults	Freshwater Adults
Salmon	Chinook				X	X	
	Chum				X	X	
	Coho				X	X	
	Pink				X	X	
	Sockeye				X	X	

The status, distribution, habitat preference (substrate, depth, temperature, and salinity), life history (migration, movements, and spawning), common prey species, and EFH designations of the species complexes and/or individual species are summarized in greater detail in an EFH Assessment prepared by the Navy.

Habitat Areas of Particular Concern (HAPCs) are a subset of EFH. FMCs are encouraged to designate HAPCs under the MSFCMA. HAPCs are identified based on habitat level considerations rather than species life stages as are identified with EFH. EFH guidelines published in federal regulations identify HAPCs as types or areas of habitat within EFH that are identified based on one or more of the following considerations:

- The importance of the ecological function provided by the habitat.
- The extent to which the habitat is sensitive to human-induced environmental degradation.
- Whether, and to what extent, development activities are or will be stressing the habitat type.
- The rarity of the habitat type (50 Code of Federal Regulations [C.F.R.] 600.815(a)(8))

Several habitat types identified as HAPCs (areas with living substrates in shallow/deep waters) focus on specific habitat locations, such as seamounts and hard coral areas (NPFMC 2005a). Amendments to the FMP for salmon fisheries in the EEZ off the coast of Alaska, the FMP for the scallop fishery off Alaska, and the FMP for groundfish of the GOA have established the following Habitat Conservation Areas and Habitat Protection Areas in the GOA: 10 Gulf of Alaska Slope Habitat Conservation Areas (GOASHCAs), 15 Alaska Seamount Habitat Protection Areas (ASHPAs), and 5 Gulf of Alaska Coral Habitat Protection Areas (NMFS 2006). Within the TMAA, one GOASHCA (Cable) and three ASHPAs (Dall, Giacomini, and Quinn Seamounts) occur almost entirely within the TMAA (Figure 1-24). Other areas, such as the Kodiak Seamount and Middleton West GOASHCA are partially located in the TMAA (see Figure 3.5-7).

Scallop Fishery Management Plan

Scallops are managed jointly by NMFS and Alaska Department of Fish and Game (ADFG) under the FMP for the Scallop Fishery off Alaska (NPFMC 2004b). This FMP covers all scallop stocks off the coast of Alaska including the weathervane (*Patinopecten caurinus*), pink (*Chlamys rubida*), spiny (*C. hastata*), and rock (*Crassadoma gigantea*), scallops representing the family Pectinidae (USDC, NOAA 2005). Of the four scallop species, the weathervane scallop is the only commercially exploited scallop in Alaskan waters that has EFH designated within the TMAA (USDC, NOAA 2005). Therefore, the other three scallop species are not discussed further. A description of EFH for the life stage that occurs within the TMAA is presented in Table 3.6-1.

Groundfish Fishery Management Plan

The GOA Groundfish FMP and its management regime govern all stocks of finfish (including squid and octopus), except salmon, steelhead, halibut, herring, and tuna. The groundfish complex separates the species into five categories: (1) prohibited species – species and/or species of groups whose catch must be returned to the sea with a minimum of injury except when their retention is authorized by other applicable law (e.g., King and Tanner crabs [*Paralithodes*/*Lithodes* spp. and *Chionoecetes* spp.], Pacific halibut, Pacific herring [*Clupea pallasii*], Pacific salmon, steelhead trout); (2) target species – commercially important species generally targeted by groundfish fishery (e.g., walleye pollock, Pacific cod); (3) other species – are not usually targeted, have little current economic value, but may contain significant components of the ecosystem or have economic potential (e.g., sharks, sculpins); (4) forage fish species – critical food source for many marine mammals, seabirds, and fish species (e.g., smelts, euphausiids); and (5) nonspecified species – species and species groups of no current economic value taken by the groundfish fishery only as incidental catch in the target fisheries (e.g., grenadiers, eelpouts, sea urchins, mussels, etc.) (USDC, NOAA 2005; NPFMC 2005a). EFH provisions of the MSFCMA do not apply to prohibited and nonspecified species (unless these species are included in the fishery management unit of another FMP), e.g., Bering Sea/Aleutian Island crab species or salmon fisheries (USDC, NOAA 2005).

Target species consist of the following groups: 13 flatfish species (right-eye flounders) consisting of a single family, 32 rockfish and two thornyheads in the family Scorpaenidae; four roundfish species representing three families; and five skate species in the family Rajidae. Other species consist of six sculpins representing two families, three sharks from three families, four squids consisting of two families, and two octopuses representing two families (see Table 3.6-1) (NPFMC 2005b). The forage fish species comprises nine fish families and one crustacean order Euphausiacea (NPFMC 2005a). EFH designation is based upon the aquatic habitat necessary for groundfish production in supporting a long-term sustainable fisheries and contributing to a healthy ecosystem (USDC, NOAA 2005). According to the Final EIS (FEIS) for EFH Identification and Conservation in Alaska, other species, such as sharks, octopi, and forage fishes are lacking sufficient information to define EFH (USDC, NOAA 2005). Therefore, of all the species or assemblages listed in the Groundfish FMP, 18 species or assemblages have sufficient information and designated EFH within the TMAA (Table 3.6-1).

Description

Fifty-nine of the 66 NPFMC managed groundfish species are known to occur in the GOA, including the TMAA (USDC, NOAA 2005). These groundfish species occupy various marine environments including estuaries, tideland marshes, bays, fjords, sandy beaches, unprotected rocky shores, river deltas, and a variety of continental shelf, slope, seamounts, and deep ocean habitats encompassing different physical and biological attributes at various stages in their life histories (Hood and Zimmerman 1986). Research on the life histories and habitats of these species varies in completeness, so while some species are well studied, there is relatively little information on other species. The status, distribution, habitat preference (substrate, depth, temperature, and salinity), life history (migration, movements, and spawning), common prey species, and EFH designations of the species complexes and/or individual species are summarized below, with greater detail provided in an EFH Assessment prepared by the Navy (NPFMC 1990, 2004b, 2005b).

The flatfishes in the GOA have been divided into several categories for management purposes. With the exception of arrowtooth flounder, rex sole, and flathead sole, which are managed as individual species, the remaining flatfishes are managed as "shallow-water" and "deepwater" assemblages (USDC, NOAA 2005). Each of the managed individual species has its own EFH designation (Table 3.6-1). The EFH designation of the Alaska plaice and rock and yellowfin soles best represents the shallow-water assemblage, whereas the Dover sole best represents the deepwater assemblage (USDC, NOAA 2005).

Status

According to NMFS (2005a) and NPFMC (2004a), no groundfish stocks are designated as overfished. The abundances of Pacific cod (*Gadus macrocephalus*), Pacific ocean perch (*Sebaste alutus*), northern rockfish (*S. polyspinis*), dusky rockfish (*S. ciliatus*), thornyheads, flathead sole (*Hippoglossoides elassodon*), Dover sole, and arrowtooth flounder are above target stock size, whereas abundances of walleye pollock are below target stock size (NPFMC 2004a). The relative abundances of other deepwater flatfish, shallow-water flatfish, rex sole, shortraker rockfish (*S. borealis*), rougheye rockfish (*S. aleutianus*), demersal shelf rockfish, other pelagic shelf rockfish, other slope rockfish, Atka mackerel (*Pleurogrammus monopterygius*), and skates are unknown (NMFS 2004a).

Currently, the various individual species comprising the groundfish complex are not listed as threatened or endangered or species of concern (formerly candidate species) under the ESA in the TMAA. Five groundfish species are on the IUCN Red List of Threatened Species. Bocaccio (*S. paucispinis*) is considered critically endangered due to an estimated reduction of at least 80 percent of its population over the last 10 years or three generations. The shortspine thornyhead (*Sebastolobus alascanus*) is considered endangered due to an estimated reduction of at least 50 percent of its population over the last 10 years or three generations. The salmon shark is listed as data deficient, and the big skate is listed as lower risk, but near threatened. The spiny dogfishes' northeast Pacific subpopulation is listed as vulnerable due to the fisheries overexploitation of this species because of its late maturity, low capacity to reproduce, longevity, generation time (25 to 40 years), and a low intrinsic population rate increase of 2 to 7 percent per year. According to the Food and Agriculture Organization (FAO), the salmon shark is listed as category 1 due to a lack of fisheries data (Castro et al. 1999).

High Seas Salmon Plan Fishery Management Plan

Description

Five species of Pacific salmon (Chinook, coho, chum, pink, and sockeye salmon) have EFH designated within the TMAA (Duffy et al. 2005). All species are similar in appearance and have an anadromous life history (USDC, NOAA 2005). Anadromous salmon depend on the ecological integrity and connectivity of a suite of habitats extending from the natal freshwater spawning or rearing streams to estuaries and then to coastal, shelf, and offshore waters for their growth (Groot and Margolis 1991). The relative importance of estuarine and coastal marine environments differs within and among the various salmon species due to differences in residence times and utilization of these environments (PICES 2004). All species of salmon spawn in gravel beds in freshwater rivers and streams, or along lake-shores (Thorpe 1994, Anchor Environmental L.L.C. and People for Puget Sound 2002). Coho and Chinook salmon typically migrate to sea after extended periods of rearing as juveniles in freshwaters; whereas pink salmon do not rear long in freshwater and migrate to sea soon after emergence from natal gravel beds (Duffy et al. 2005). Juvenile salmon reside mainly in nearshore intertidal waters, which provide five key functions:

migration corridors, food production, physiological refuge, refuge from predators, and high-energy refuge (Good et al. 2005). After achieving some size threshold or after a temporal cue (e.g., a specific residence time), salmon move from shallow nearshore to offshore surface waters in estuarine and marine waters (NMFS 2005b, 2005c, USFWS 2005).

EFH Designations

Salmon EFH includes streams, lakes, ponds, wetlands, and other water bodies currently or historically accessible to salmon. The geographic extent of marine EFH for salmon extends from the nearshore and tidal submerged environments within state territorial seas out to the full extent of the Exclusive Economic Zone (EEZ), 200 nm offshore (PFMC 2000, USDC; NOAA 2005). Freshwater EFH for salmon (streams, lakes, ponds, or wetlands) is not within the TMAA. For more information on freshwater EFH, see USDC, NOAA (2005).

Status

None of these high seas salmon are currently listed on the International Union for Conservation of Nature and Natural Resources (IUCN) red list of threatened species. Those species listed under the ESA are discussed in Section 3.6.1.3.

3.6.1.3 Threatened and Endangered Species

The Navy is currently conducting ESA Section 7 consultations with NMFS to address effects to listed fish species for the Preferred Alternative (Alternative 2).

Federally listed species of fish are identified by Evolutionarily Significant Units (ESUs) or Distinct Population Segments (DPSs). This policy indicates that one or more naturally reproducing populations will be considered to be distinct population segments and, hence, a species under the ESA, if they represent an ESU or DPS of the biological species. To be considered an ESU, a population must satisfy two criteria: (1) It must be reproductively isolated from other population units of the same species, and (2) it must represent an important component in the evolutionary legacy of the biological species (Good et al. 2005). The first criterion, reproductive isolation, need not be absolute but must have been strong enough to permit evolutionarily important differences to occur in different population units. The second criterion is met if the population contributes substantially to the ecological or genetic diversity of the species as a whole (NMFS 1999). The DPS policy adopts criteria similar to, but somewhat different from, those in the ESU policy for determining when a group of vertebrates constitutes a DPS: the group must be discrete from other populations and it must be significant to its taxon (NMFS 2006).

Once an ESU or DPS is listed, the ESA requires NOAA and USFWS to designate “critical habitat” for the species. “Critical habitat” is defined as: 1) specific areas within the geographical area occupied by the species at the time of listing, if they contain physical or biological features essential to conservation, and those features may require special management considerations or protection; and 2) specific areas outside the geographical area occupied by the species if the agency determines that the area itself is essential for conservation.

Salmonids

Various listed ESUs or DPSs of salmonids (Chinook salmon, coho salmon, chum salmon, sockeye salmon, and steelhead) migrate north to mature in the GOA and may occur in the TMAA (Table 3.6-3). While these listed salmonids have designated critical habitat, none of the critical habitat occurs within the TMAA. Salmon (Chinook and coho, in particular) support important traditional, commercial, and recreational fisheries in the GOA and have long been an integral part of the Native American culture (NPFMC 1990). Salmon are extremely important to both marine and terrestrial ecosystems (Gende et al. 2002).

Table 3.6-3: Pacific Salmonid ESUs and DPSs in the TMAA and Vicinity

Species	ESU	ESA Listing Status	Critical Habitat in TMAA
Chinook Salmon	Sacramento River Winter-run	Endangered	No
	Upper Columbia River Spring-run	Endangered	No
	Snake River Spring/Summer-run	Threatened	No
	Snake River Fall-run	Threatened	No
	Central Valley Spring-run	Threatened	No
	California Coastal	Threatened	No
	Puget Sound	Threatened	No
	Lower Columbia River	Threatened	No
	Upper Willamette River	Threatened	No
Coho Salmon	Central California Coast	Endangered	No
	Southern Oregon / Northern California Coasts	Threatened	No
	Lower Columbia River	Threatened	No
	Oregon Coast	Threatened	No
Chum Salmon	Hood Canal Summer-run	Threatened	No
	Columbia River	Threatened	No
Sockeye Salmon	Snake River	Endangered	No
	Ozette Lake	Threatened	No
Steelhead Trout	Southern California	Endangered	No
	Upper Columbia River	Threatened	No
	Snake River Basin	Threatened	No
	Middle Columbia River	Threatened	No
	Lower Columbia River	Threatened	No
	Upper Willamette River	Threatened	No
	South-Central California Coast	Threatened	No
	Central California Coast	Threatened	No
	Northern California	Threatened	No
	California Central Valley	Threatened	No
	Puget Sound	Threatened	No

Source: NMFS 2009

Chinook Salmon

The Chinook salmon's historical range in North America extended from the Ventura River in California to Point Hope, Alaska (Myers et al. 1998). The natural freshwater range for Chinook salmon extends throughout the Pacific Rim of North America. This species has been identified from the San Joaquin River in California to the Mackenzie River in northern Canada (Healey 1991). The oceanic range encompasses Washington, Oregon, California, throughout the north Pacific Ocean, and as far south as the U.S./Mexico border (PFMC 2000). Offshore ocean distribution is generally more limited (within 200 miles [mi] of the coast) for Chinook than other Pacific salmonids (NPFMC 1990).

Chinook salmon exhibit one of the more diverse and complex life history strategies of all Pacific salmon and are separated into two generalized life-history types: stream-type and ocean-type (Myers et al. 1998, PFMC 2000). Timing of migration to seawater for juveniles is highly variable (PFMC 2000). Ocean-type juveniles may migrate to the ocean immediately after hatching in the late winter or early spring, but most remain in freshwater for 30 to 90 days (USDC, NOAA 2005). Ocean-type juveniles typically inhabit estuaries for several months before migrating to higher salinity waters (PFMC 2000). Stream-type juveniles pass quickly through estuaries, are highly migratory, and may make extensive migrations in the open ocean (USDC, NOAA 2005). Fry enter the upper reaches of estuaries in late winter for the more southern populations or early spring for the more northern populations (PFMC 2000). For a year or more, they reside as fry or parr in freshwater where they exhibit downstream dispersal and utilize a variety of freshwater rearing environments before migrating to sea (Healey 1991). They perform extensive offshore oceanic migrations and return to their natal river during the spring and early summer, several months prior to spawning (Healey 1991). Ocean residency varies but may last from 1 to 6 years (Healey 1991). Stream-type adults often enter freshwater in the spring and summer as immature fish and spawn in upper watersheds in late summer or early fall (PFMC 2000). Stream-type life histories are most common in Alaska, but ocean-type populations are also present in a few watersheds (USDC, NOAA 2005).

Ocean-type Chinook migrate to the ocean within the first year (typically within a few months) after emergence where they spend an average of 4 to 5 years. (Myers et al. 1998, PFMC 2000, Augerot and Foley 2005). Ocean-type Chinook salmon spend most of their ocean life in coastal waters, and return to their natal rivers from spring to winter (Healey 1991). Spawning may range from May/June to December/January depending on location but periods are specific for each run and/or stock (Emmett et al. 1991, Healey 1991, PFMC 2000). Spawning may occur from the tidewater to 1,988 mi (3,200 km) upstream (Healey 1991). Stream-type and ocean-type spawning populations are separated considerably (Healey 1991). In North America there seems to be a sudden shift from stream-type to ocean-type stocks somewhere around Alaska-British Columbia border (Healey 1991). South of approximately 56°N, stream-type Chinook are only found in larger rivers with ocean-type salmon dominating the majority of the runs (Healey 1991).

Chinook salmon may return to their natal streams during any month but there are one to three peaks associated with salmon migratory activity (Healey 1991). These peaks vary between river systems. Northern river systems generally see a single peak in migratory activity around June, although runs can possibly occur from April to August (Healey 1991). As you go farther south, runs occur progressively later (Healey 1991).

Within the TMAA, early life history stages for Chinook occur in freshwater but juveniles and adults utilize marine habitats. Juvenile Chinook prefer coastal areas (less than 34 mi [55 km]) throughout California, Oregon, and Washington, north to the Strait of Georgia and the Inland Passage, Alaska (PFMC 2000). The majority of marine juveniles are found within 17 mi (28 km) of the coast (PFMC 2000). They tend to concentrate around areas of pronounced coastal upwellings (PFMC 2000). Populations originating north of Cape Blanco, Oregon migrate north to the GOA, while populations originating south of Cape Blanco migrate south and west into the waters off California and Oregon (PFMC 2000). Chinook salmon spawning in rivers south of the Rogue River in Oregon rear in marine waters off California and Oregon, whereas, salmon spawning in rivers north of the Rogue River migrate north and west along the Pacific coast (USDC, NOAA 2005). These migrations are important from a management perspective since fish from Oregon, Washington, British Columbia, and Alaska have the potential of being harvested in the GOA (USDC, NOAA 2005).

Coho Salmon

Coho salmon are found in freshwater drainages from Monterey Bay, California north along the west coast of North America to Alaska, around the Bering Sea south through Russia to Hokkaido, Japan (California Department of Fish and Game [CDFG] 2002). Oceanic lifestages are found from Camalu Bay, Baja California north to Point Hope, Alaska and through the Aleutian Islands (Marine Biological Consultants [MBC] 1987, Sandercock 1991, USDC, NOAA 2005). In the northeastern Pacific, coho can be found south of 40°N, but only in the coastal waters of the California Current (MBC 1987). Tagging studies have shown coho originating from Washington and Oregon as far north as 60°N latitude and coho originating from California as far north as 58°N latitude (PFMC 2000). Oregon coho have been taken in offshore waters near Kodiak Island in the northern Gulf of Alaska. Westward migration of coho salmon appears to extend beyond the EEZ beginning at approximately 45°N latitude off the coast of Oregon (PFMC 2000). In strong upwelling years coho are more dispersed offshore, whereas in weak upwelling years they concentrate near submarine canyons and areas of consistent upwelling.

Adult coho migrate into streams where they deposit their eggs in gravel (Sandercock 1991). Eggs incubate throughout the winter and emerge in the spring as free-swimming fry (Sandercock 1991). Typical freshwater and estuarine residency time in Alaska is one to two years, though coho may spend up to 5 years if their growth is slow (USDC, NOAA 2005). Juveniles spend a minimum of 18 months at sea before returning to their natal streams to repeat the process (NPFMC 1990, Sandercock 1991).

Adult coho salmon migrate to their natal streams from June to February with northern populations beginning their return earlier than southern populations (Emmett et al. 1991, Sandercock 1991). Throughout their range, coho exhibit a variety of return timing patterns (Sandercock 1991). Most juvenile migration occurs from April to August with a peak in May (Emmett et al. 1991). Generally, as you move farther north, estuarine residency time for juveniles increases (PFMC 2000). Upon entering the ocean, coho may spend several weeks or their entire first summer in coastal waters before migrating north (PFMC 2000). In Alaska, coho spend up to 4 months in coastal waters before migrating offshore (USDC, NOAA 2005). Tag, release, and recovery studies suggest that coho salmon of California origin can be found as far north as southeast Alaska and salmon from Oregon and Washington as far north as the northern GOA (PFMC 2000). The extent of coho migrations appears to extend westward along the Aleutian Island chain ending somewhere around Emperor Seamount (believed to be an area of high prey abundance; PFMC 2000). The southern extent of the population expands and contracts annually, with Point Conception, California generally considered the faunal break for the coho and other temperate marine species (PFMC 2000). Offshore, juvenile coho are generally found in waters over the continental shelf, ranging from 23 to 46 mi (37 to 74 km) from shore (USDC, NOAA 2005). Adult coho may enter freshwater as early as July in the Alaska and as late as December or January in California (Sandercock 1991, PFMC 2000). Summer-run coho may enter rivers exceptionally early (spring or early summer; PFMC 2000). Larger rivers have a wider range of entry times than smaller systems (PFMC 2000).

Because of the coho’s extended residency in freshwater environments (streams, ponds, and lakes), they are especially vulnerable to anthropogenic activities such as timber harvesting, mining, and road building (NPFMC 1990). Catch rates for coho in Alaska are at historically high levels and most stocks are rated as stable (USDC, NOAA 2005).

Chum Salmon

Chum salmon have the largest range of natural geographic and spawning distribution of all the Pacific salmon species (Pauley et al. 1988). Historically, in North America, chum salmon occurred from Monterey, California to the Arctic coast of Alaska and east to the Mackenzie River which flows into the Beaufort Sea. Present spawning populations are now found only as far south as Tillamook Bay on the northern Oregon coast (Salo 1991). Juvenile chum occur along the coast of North America and Alaska in a band that extends out to 22 mi (36 km) (Salo 1991).

Chum salmon are an anadromous species distributed throughout the North Pacific Ocean (Salo 1991). They are highly migratory with fry heading seaward immediately after emergence (NPFMC 1990, Salo 1991). Chum salmon do not have the clearly defined smolt stages that occur in other salmonids; however they are capable of adapting to seawater soon after emergence from the gravel (Salo 1991). Migrations of juvenile chum are correlated with the warming of nearshore waters (Salo 1991). They migrate to estuaries during their first spring or summer and spend little time rearing in freshwater (Pauley et al. 1988).

Juveniles enter estuaries from March to mid-May where they remain for several months (Emmett et al. 1991). As chum salmon grow, there is a general movement toward the ocean, moving offshore from April to June (Emmett et al. 1991). They then head north along the continental shelf until they reach the Gulf of Alaska (Emmett et al. 1991). Adults return to their natal streams at various ages but generally within 2 to 5 years (Salo 1991). Chum salmon return to their natal streams from June to January with more northern populations returning earlier than those to the south (USDC, NOAA 2005). The majority of chum spawning in Alaska is finished by November (USDC, NOAA 2005). For chum salmon, two spawning stocks exist: a northern stock that spawns from June to September and a southern (late-run) stock that spawns from August to January (Emmett et al. 1991).

Within the TMAA, early life history stages for chum salmon occur in freshwater but juveniles and adults utilize marine habitats. Juvenile chum migrations follow the GOA coastal belt to the north, west, and south during their first summer at sea (Salo 1991). While overall migration patterns of juvenile chum salmon within the GOA are understood, nearshore residency times and offshore migrations patterns are still unclear (Salo 1991). Migrations of immature fish during the late summer, fall, and winter occur in a broad southeasterly fashion, primarily south of 50°N and east of 155°W in the GOA. During the spring and early summer, chum salmon migrate to the north and west (Salo 1991). Maturing fish destined for North American streams are widely distributed throughout the GOA during the spring and summer (Salo 1991).

Sockeye Salmon

The sockeye salmon are primarily anadromous, where they migrate as juveniles from freshwater habitats to marine environments and return to freshwater habitats to spawn, but there are also distinct landlocked populations (kokanee) which never migrate to marine waters, spending their entire life cycle in fresh water habitats (Burgner 1991, Emmett et al. 1991).

After emergence, sockeye typically rear in lakes or glacial river sloughs for 1 to 3 years before migrating to the ocean (NPFMC 1990, Burgner 1991). Anadromous sockeye spend 1 to 4 years at sea before returning to their natal streams in the summer and autumn to spawn and eventually die. Offshore movements of sockeye are complex and are affected by a variety of physical factors (e.g., season, temperature, and salinity) and biological factors (e.g., life stage, age and size, availability and distribution of prey, and stock-of-origin; Burgner 1991). Juveniles generally remain in a band close to the coast upon entering the ocean environment (USDC, NOAA 2005). In British Columbia and southeast Alaska, juveniles are usually present in the open sea by late June. These fish are found moving northwestward into the GOA during July. This northwestward movement up the eastern Pacific Rim is followed by a southwestward migration along the Alaskan Peninsula (USDC, NOAA 2005).

In North America, spawning populations are found from the Sacramento River in California, north to Kotzebue Sound (Burgner 1991). Spawning is temperature-dependent and varies by location generally occurring from August to December and peaking in October (Emmett et al. 1991). Sockeye generally spawn in streams associated with lakes where the juveniles rear in the limnetic zone before they smoltify and migrate to the ocean (Pauley et al. 1989, Burgner 1991, Emmett et al. 1991). For this reason, the two largest spawning complexes are the Bristol Bay watershed in southwestern Alaska and the Fraser River watershed in British Columbia, both of which have extensive lake rearing habitats accessible to sockeye (Burgner 1991).

Within the TMAA, early life history stages for sockeye occurs in lakes and streams, but juveniles and adults utilize marine habitats and vicinity. Seaward migrations in Alaska begin in mid-May in association with salinity gradients (NPFMC 1990). Soon after entering the ocean, juvenile sockeye (excluding those from Bristol Bay) begin moving north into the GOA where they remain along the coastal belt until late-fall or early-winter. They then disperse offshore moving west and south (Emmett et al. 1991). In the

GOA, sockeye move north during the spring and summer and south and west during the winter (Emmett et al. 1991). Ocean residency for sockeye is 1 to 4 years (Pauley et al. 1989).

Steelhead Trout

Steelhead trout exhibit a great diversity of life history patterns, and are phylogenetically and ecologically complex. Steelhead may exhibit either an anadromous life style, or a freshwater residency, where they spend their entire life in freshwater (NMFS 1997). Freshwater residents are referred to as rainbow trout. Different life history forms include anadromous and nonanadromous, winter or summer steelhead, inland or coastal groupings, and half-pounder strategies. Some anadromous forms spend up to 7 years in freshwater and 3 years in the ocean prior to their first spawning (Busby et al. 1996), while other anadromous steelhead typically spend the first 2 years of their lives in freshwater, migrate to the marine environment and spend 2 to 3 years there, before returning to the freshwater environment to spawn at 4 to 5 years of age (McEwan and Jackson 1996, Schultz 2004).

Steelhead have excellent homing abilities and have been separated into two races depending on their return to their natal stream (winter-run and summer-run; Emmett et al. 1991). Winter-run steelhead migrate upstream during the fall, winter, and early spring, whereas summer-run steelhead migrate during the spring, summer, and early fall (Emmett et al. 1991). Winter steelhead enter their home stream in various stages of sexual maturation from November to April, and spawn within a few months of entering the river between late March and early May (Pauley et al. 1986). They are the most widespread of the two reproductive types. Coastal streams are dominated by winter steelhead, and there are only a few occurrences of inland winter steelhead populations (Busby et al. 1996). Juveniles generally rear in freshwater for 1 to 4 years before migrating to the ocean where they reside from 1 to 5 years (Emmett et al. 1991). Steelhead may also exhibit a “half-pounder” run (mostly summer steelhead) where they return to natal streams after only a few months at sea, overwinter, and then migrate back to the ocean (Emmett et al. 1991). Steelhead spend little time in estuaries and are abundant throughout the North Pacific and Gulf of Alaska (Emmett et al. 1991).

Spawning typically occurs from December to June; peaks are in February and March (McEwan and Jackson 1996). Steelhead can spawn more than once (iteroparity); all other species of Pacific *Oncorhynchus* spawn once and then die (semelparity). North of Oregon, repeat spawning is relatively uncommon and more than two spawning migrations is rare. Iteroparity occurs predominantly in females (Busby et al. 1996).

In the TMAA and vicinity, early life history stages of the steelhead are found only in freshwater habitats, while the later life history stages of the anadromous life form (i.e., juveniles and adults) utilize the marine environment. In the spring, Alaskan steelhead smolt leave their natal streams and enter the ocean where they reside for 1 to 3 years before returning to spawn (USDC, NOAA 2005). Populations may return in July (summer-run) or in August, September, and October (fall-run; USDC, NOAA 2005). Summer returns are rare in Alaska and are only found in a few southeast Alaska streams. Fall-run steelhead are much more common in Alaska, north of Frederick Sound, and are found in rivers, such as the Anchor, Nahu, Karluk, and Situk. Steelhead also exhibit spring runs (April, May, and June), but they are predominately found in southeast Alaska.

3.6.1.4 Hearing in Fish

All fish have two sensory systems that are used to detect sound in the water including the inner ear, which functions very much like the inner ear found in other vertebrates, and the lateral line, which consists of a series of receptors along the body of the fish (Popper 2008). The inner ear generally detects higher frequency sounds while the lateral line detects water motion at low frequencies (below a few hundred Hz) (Hastings and Popper 2005). A sound source produces both a pressure wave and motion of the medium particles (water molecules in this case), both of which may be important to fish. Fish detect particle motion with the inner ear. Pressure signals are initially detected by the gas-filled swim bladder or other air pockets in the body, which then re-radiate the signal to the inner ear (Popper 2008). Because particle motion attenuates relatively quickly, the pressure component of sound usually dominates as distance from the source increases.

The lateral line system of a fish allows for sensitivity to sound (Hastings and Popper 2005). This system is a series of receptors along the body of the fish that detects water motion relative to the fish that arise from sources within a few body lengths of the animal. The sensitivity of the lateral line system is generally from below 1 Hz to a few hundred Hz (Coombs and Montgomery 1999, Webb et al. 2008). The only study on the effect of exposure to sound on the lateral line system (conducted on one freshwater species) suggests no effect on these sensory cells by intense pure tone signals (Hastings et al. 1996). While studies on the effect of sound on the lateral line are limited, Hasting et al.'s (1996) work, showing limited sensitivity to within a few body lengths and to sounds below a few hundred Hz, make the effect of the mid-frequency sonar of the Proposed Action unlikely to affect a fish's lateral line system. Therefore, further discussion of the lateral line in this analysis in unwarranted.

Broadly, fish can be categorized as either hearing specialists or hearing generalists (Scholik and Yan 2002). Fish in the hearing specialist category have a broad frequency range with a low auditory threshold due to a mechanical connection between an air filled cavity, such as a swimbladder, and the inner ear. Specialists detect both the particle motion and pressure components of sound and can hear at levels above 1 kilohertz (kHz). Generalists are limited to detection of the particle motion component of low-frequency sounds at relatively high sound intensities (Amoser and Ladich 2005). It is possible that a species will exhibit characteristics of generalists and specialists and will sometimes be referred to as an "intermediate" hearing specialist. For example, most damselfish are typically categorized as generalists, but because some larger damselfish have demonstrated the ability to hear higher frequencies expected of specialists, they are sometimes categorized as intermediate.

Of the fish species with distributions overlapping the TMAA for which hearing sensitivities are known, most are hearing generalists, including salmonid species.

Although hearing capability data only exists for fewer than 100 of the 29,000 fish species (Popper 2008), current data suggest that most species of fish detect sounds from 0.05 to 1.0 kHz, with few fish hearing sounds above 4 kHz (Popper 2008). Moreover, studies indicate that hearing specializations in marine species are quite rare and that most marine fish are considered hearing generalists (Popper 2003, Amoser and Ladich 2005). Specifically, the following species are all believed to be hearing generalists: elasmobranchs (i.e., sharks and rays) (Casper et al. 2003, Casper and Mann 2006, Myrberg 2001), scorpaeniforms (i.e., scorpionfishes, searobins, sculpins) (Lovell et al. 2005), scombrids (i.e., albacores, bonitos, mackerels, tunas) (Iversen 1967, Iversen 1969, Popper 1981, Song et al. 2006), damselfishes (Egner and Mann 2005, Kenyon 1996, Wright et al. 2005, Wright et al. 2007), and more specifically, midshipman fish (*Porichthys notatus*) (Sisneros and Bass 2003), Atlantic salmon (*Salmo salar*) (Hawkins and Johnstone 1978), and Gulf toadfish (*Opsanus beta*) (Remage-Healey et al. 2006). Moreover, it is believed that the majority of marine fish have their best hearing sensitivity at or below 0.3 kHz (Popper 2003). However, it has been demonstrated that marine hearing specialists, such as some Clupeidae, can detect sounds above 100 kHz. A list of fish hearing sensitivities is presented in Table 3.6-4.

In contrast to marine fish, several thousand freshwater species are thought to be hearing specialists. Nelson (1994) estimates that 6,600 of 10,000 freshwater species are otophysans (catfish and minnows), which are hearing specialists. Interestingly, many generalist freshwater species, such as perciforms (percids, gobiids) and scorpaeniforms (sculpins) are thought to have derived from marine habitats (Amoser and Ladich 2005). It is also thought that Clupeidae may have evolved from freshwater habitats

(Popper et al. 2004). This supports the theory that hearing specializations likely evolved in quiet habitats common to freshwater and the deep sea because only in such habitats can hearing specialists use their excellent hearing abilities (Amoser and Ladich 2005).

Table 3.6-4: Marine Fish Hearing Sensitivities

Family	Description of Family	Common Name	Scientific Name	Hearing Range (kHz)		Greatest Sensitivity (kHz)	Sensitivity Classification
				Low	High		
Albulidae	Bonefishes	Bonefish	*Albula vulpes*	0.1	0.7	0.3	Generalist
Anguillidae	Eels	European eel	*Anguilla anguilla*	0.01	0.3	0.04-0.1	Generalist
Ariidae	Catfish	Hardhead sea catfish	*Ariopsis felis*	0.05	1	0.1	Generalist
Batrachoididae	Toadfishes	Midshipman	*Porichthys notatus*	.065	0.385		Generalist
		Gulf toadfish	*Opsanus beta*			<1	Generalist
Clupeidae	Herrings, shads, menhadens, sardines	Alewife	*Alosa pseudoharengus*		0.12		Specialist
		Blueback herring	*Alosa aestivalis*		0.12		Specialist
		American shad	*Alosa sapidissima*	0.1	0.18	0.2-0.8 and 0.025-0.15	Specialist
		Gulf menhaden	*Brevoortia patronus*		0.1		Specialist
		Bay anchovy	*Anchoa mitchilli*		4		Specialist
		Scaled sardine	*Harengula jaguana*		4		Specialist
		Spanish sardine	*Sardinella aurita*		4		Specialist
		Pacific herring	*Clupea pallasii*	0.1	5		Specialist
Chondrichthyes [Class]	Cartilaginous fishes, rays, sharks, skates			0.2	1		Generalist
Gadidae	Cods, gadiforms, grenadiers, hakes	Cod	*Gadus morhua*	0.002	0.5	0.02	Generalist
Gobidae	Gobies	Black goby	*Gobius niger*	0.1	0.8		Generalist
Holocentridae	Squirrelfish and soldierfish	Shoulderbar soldierfish	*Myripristis kuntee*	0.1	3.0	0.4-0.5	Specialist
		Hawaiian squirrelfish	*Adioryx xantherythrus*	0.1	0.8		Generalist
Labridae	Wrasses	Tautog	*Tautoga onitis*	0.01	0.5	0.037-0.050	Generalist
		Blue-head wrasse	*Thalassoma bifasciatum*	0.1	1.3	0.3-0.6	Generalist
Lutjanidae	Snappers	Schoolmaster snapper	*Lutjanus apodus*	0.1	1.0	0.3	Generalist
Myctophidae	Lanternfishes	Warming's lanternfish	*Ceratoscopelus warmingii*				Specialist
Pleuronectidae	Flatfish, including Pacific halibut	Dab	*Limanda limanda*	0.03	0.27	0.1	Generalist
		European plaice	*Pleuronectes platessa*	0.03	0.2	0.11	Generalist

Table 3.6-4: Marine Fish Hearing Sensitivities (continued)

Family	Description of Family	Common Name	Scientific Name	Hearing Range (kHz)		Greatest Sensitivity (kHz)	Sensitivity Classification
				Low	High		
Pomadasyidae	Grunts	Blue striped grunts	*Haemulon sciurus*	0.1	1.0		Generalist
Pomacentridae	Damselfish	Sergeant major damselfish	*Abudefduf saxatilis*	0.1	1.6	0.1-0.4	Generalist/ Intermediate
		Bicolor damselfish	*Stegastes partitus*	0.1	1.0	0.5	Generalist/ Intermediate
		Nagasaki damselfish	*Pomacentrus nagasakiensis*	0.1	2.0	<0.3	Generalist/ Intermediate
Salmonidae	Salmons	Atlantic salmon	*Salmo salar*	<0.1	0.58		Generalist
Sciaenidae	Drums, weakfish, croakers	Atlantic croaker	*Micropogonias undulatus*	0.1	1.0	0.3	Generalist
		Spotted sea trout	*Cynoscion nebulosus*				Generalist
		Kingfish	*Menticirrhus americanus*				Generalist
		Spot	*Leiostomus xanthurus*	0.2	0.7	0.4	Generalist
		Black drum	*Pogonias cromis*	0.1	0.8	0.1-0.5	Generalist
		Weakfish	*Cynoscion regalis*	0.2	2.0	0.5	Specialist
		Silver perch	*Bairdiella chrysoura*	0.1	4.0	0.6-0.8	Specialist
Scombridae	Albacores, bonitos, mackerels, tunas	Bluefin tuna	*Thunnus thynnus*		1.0		Generalist
		Yellowfin tuna	*Thunnus albacares*	0.5	1.1		Generalist
		Kawakawa	*Euthynnus affinis*	0.1	1.1	0.5	Generalist
		Skipjack tuna	*Katsuwonus pelamis*				Generalist
Scorpaenidae	Scorpionfishes searobins, sculpins	Sea scorpion	*Taurulus bubalis*				Generalist
Serranidae	Seabasses, groupers	Red hind	*Epinephelus guttatus*	0.1	1.1	0.2	Generalist
Sparidae	Porgies	Pinfish	*Lagodon rhomboides*	0.1	1.0	0.3	Generalist
Triglidae	Scorpionfish, searobins, sculpins	Leopard searobin	*Prionotus scitulus*	0.1	0.8	0.39	Generalist

Sources: Astrup 1999; Astrup and Mohl 1993; Casper and Mann 2006; Casper et al. 2003; Coombs and Popper 1979; Dunning et al. 1992; Egner and Mann 2005; Gregory and Clabburn 2003; Hawkins and Johnstone 1978; Higgs et al. 2004; Iversen 1967, 1969; Jorgensen et al. 2005; Kenyon 1996; Lovell et al. 2005; Mann et al. 1997, 2001, 2005; Myrberg 2001; Nestler 2002; Popper 1981, 2008; Popper and Carlson 1998; Popper and Tavolga 1981; Ramcharitar and Popper 2004; Ramcharitar et al. 2001, 2004, 2006a; Remage-Healey et al. 2006; Ross et al. 1996; Sisneros and Bass 2003; Song et al. 2006; Wright et al. 2005, 2007

Some investigators (e.g., Amoser and Ladich 2005) hypothesize that, within a family of fish, different species can live under different ambient sound conditions, which requires them to adapt their hearing abilities. Under this scenario, a species' probability of survival would be greater if it increased the range over which the acoustic environment, consisting of various biotic (sounds from other aquatic animals) and abiotic (wind, waves, precipitation) sources, could be detected. For the marine environment, Amoser and

Ladich (2005) cite the differences in the hearing ability of two species of Holocentridae as a possible example of such environmentally-derived specialization. Both the shoulderbar soldierfish (*Myripristis kuntee*) and the Hawaiian squirrelfish (*Adioryx xantherythrus*) can detect sounds at 0.1 kHz. However, the high-frequency end of the auditory range extends towards 3 kHz for the shoulderbar soldierfish but only to 0.8 kHz for the Hawaiian squirrelfish (Coombs and Popper 1979). Though these two species live in close proximity on the same reefs, it is not certain that differing environmental conditions cause the hearing variations (Popper 2008). Wysocki and Ladich (2005) suggest that ambient sound regimes may limit acoustic communication and orientation of hearing specialists in particular. Generally, a clear correlation between hearing capability and the environment cannot be asserted or refuted due to limited knowledge of ambient sound levels in marine habitats and a lack of comparative studies.

Susceptibility to the effects of anthropogenic sounds has been shown to be influenced by developmental and genetic differences in the same species of fish. In an exposure experiment, Popper et al. (2007) found that experimental groups of rainbow trout had substantial differences in hearing thresholds. While fish were attained from the same supplier, it is possible different husbandry techniques may be the reason for the differences in hearing sensitivity. These results emphasize that caution should be used in extrapolating data beyond their intent.

Among all fishes studied to date, perhaps the greatest variability is found within the family Sciaenidae (i.e., drumfish, weakfish, croaker), where there is extensive diversity in inner ear structure and the relationship between the swim bladder and the inner ear. Specifically, the Atlantic croaker's (*Micropogonias undulatus*) swim bladder has forwardly directed diverticulae that come near the ear but do not actually touch it. However, the swim bladders in the spot (*Leiostomus xanthurus*) and black drum (*Pogonias cromis*) are further from the ear and lack anterior horns or diverticulae. These differences are associated with variation in both sound production and hearing capabilities (Ladich and Popper 2004; Ramcharitar et al. 2006a). Ramcharitar and Popper (2004) discovered that the black drum responded to sounds from 0.1 to 0.8 kHz and was most sensitive between 0.1 and 0.5 kHz, while the Atlantic croaker responded to sounds from 0.1 to 1 kHz and was most sensitive at 0.3 kHz. Additional sciaenid research by Ramcharitar et al. (2006b) investigated the hearing sensitivity of weakfish (*Cynoscion regalis*) and spot. Weakfish were found to detect frequencies up to 2 kHz, while spot detected frequencies only up to 0.7 kHz.

The sciaenid with the greatest hearing sensitivity discovered thus far is the silver perch (*Bairdiella chrysoura*), which has demonstrated auditory thresholds similar to goldfish, responding to sounds up to 4 kHz (Ramcharitar et al. 2004). Silver perch swim bladders have anterior horns that terminate close to the ear. The Ramcharitar et al. (2004) research supports the suggestion that the swim bladder can potentially expand the frequency range of sound detection. Furthermore, Sprague and Luczkovich (2004) calculated silver perch are capable of producing drumming sounds ranging from 128 to 135 decibels (dB). Since drumming sounds are produced by males during courtship, it can be inferred that silver perch detect sounds within this range.

The most widely noted hearing specialists are otophysans (i.e., members of the super order Ostariophysi), which have bony Weberian ossicles (bones that connect the swim bladder to the ear), along which vibrations are transmitted from the swim bladder to the inner ear (Amoser and Ladich 2003). However, only a few otophysans inhabit marine waters. In an investigation of a marine otophysan, the hardhead sea catfish (*Ariopsis felis*), Popper and Tavolga (1981) determined that this species was able to detect sounds from 0.05 to 1 kHz, which is considered a much lower and narrower frequency range than that common to freshwater otophysans (i.e., above 3 kHz) (Ladich and Bass 2003). The difference in hearing capabilities in the respective freshwater and marine catfish appears to be related to the inner ear structure (Popper and Tavolga 1981).

Experiments on marine fish have obtained responses to frequencies between 40 kHz and 180 kHz (University of South Florida 2007). These responses were from several species of the Clupeidae (i.e., herrings, shads, and menhadens) (Astrup 1999); however, not all clupeid species tested have responded and species that can detect these high frequency sounds do not perceive sound equally well at all detectable frequencies. Studies conducted on the following species showed avoidance to sound at frequencies over 100 kHz: alewife (*Alosa pseudoharengus*) (Dunning et al. 1992, Ross et al. 1996), blueback herring (*A. aestivalis*) (Nestler 2002), Gulf menhaden (*Brevoortia patronus*) (Mann et al. 2001) and American shad (*A. sapidissima*) (Popper and Carlson 1998). The highest frequency to solicit a response in any marine fish was 180 kHz for the American shad (Mann et al. 1998, Gregory and Clabburn 2003, Higgs et al. 2004).

Astrup (1999) and Mann et al. (1998) hypothesized that high frequency detecting species may have developed such high sensitivities to avoid predation by odontocetes (i.e., members of the suborder of cetaceans that have teeth). Mann et al. (1998) reported that the American shad can detect sounds from 0.1 to 180 kHz with two regions of best sensitivity: one from 0.2 to 0.8 kHz, and the other from 25 kHz to 150 kHz. The poorest sensitivity was found from 3.2 kHz to 12.5 kHz. The *Alosa* species have relatively low thresholds (about 145 dB re 1 micropascal [µPa]), which should enable the fish to detect odontocete clicks at distances up to about 656 feet (ft) (200 meters [m]) (Mann et al. 1997). For example, echolocation clicks ranging from 200 to 220 dB could be detected by shad with a hearing threshold of 170 dB at distances from 82 to 591 ft (25 to 180 m) (University of South Florida 2007). In contrast, the Clupeidae bay anchovy (*Anchoa mitchilli*), scaled sardine (*Harengula jaguana*), and Spanish sardine (*Sardinella aurita*) did not respond to frequencies over 4 kHz (Gregory and Clabburn 2003, Mann et al. 2001).

Mann et al. (2005) found hearing thresholds (0.1 kHz to 5 kHz) for Pacific herring (*Clupea pallasii*) that were typical of non-high frequency detecting clupeids and that Pacific herring could not detect high frequency signals at received levels up to 185 dB re 1 µPa. Mann et al. (2005) cautioned that an earlier study by Wilson and Dill (2002) seeming to indicate Pacific herring responded to high frequency actually used a broadband sound source that contained less energy above 4 kHz (in the mid-frequency to high frequency range) therefore, it was not clear whether the herring were responding to the higher energy, lower-frequency components of the experiment or to the mid and high frequency.

Although few non-clupeid species have been tested for responses to high frequency sound (Mann et al. 2001), the only other non-clupeid species shown to possibly be able to detect high frequency is the cod (*Gadus morhua*) (Astrup and Mohl 1993). However, in Astrup and Moh's (1993) study it is feasible that the cod was detecting the stimulus using touch receptors that were over driven by very intense fish-finding sonar emissions (Astrup 1999, Ladich and Popper 2004). Nevertheless, Astrup and Mohl (1993) indicated that cod have high frequency thresholds of up to 38 kHz at 185 to 200 dB re 1 µPa, which likely only allows for detection of odontocete's clicks at distances no greater than 33 to 98 ft (10 to 30 m) (Astrup 1999).

As mentioned above, investigations into the hearing ability of marine fishes have most often yielded results exhibiting poor hearing sensitivity. Experiments on elasmobranch fish (i.e., sharks and rays) have demonstrated poor hearing abilities and frequency sensitivity from 0.02 kHz to 1 kHz, with best sensitivity at lower ranges (Casper et al. 2003, Casper and Mann 2006, Myrberg 2001). Though only five elasmobranch species have been tested for hearing thresholds, it is believed that all elasmobranchs will only detect low-frequency sounds because they lack a swim bladder, which resonates sound to the inner ear. Theoretically, fishes without an air-filled cavity are limited to detecting particle motion and not pressure and, therefore have poor hearing abilities (Casper and Mann 2006).

By examining the morphology of the inner ear of bluefin tuna (*Thunnus thynnus*), Song et al. (2006) hypothesized that bluefin tuna probably do not detect sounds too much over 1 kHz (if that high). This research concurred with the few other studies conducted on tuna species. Iversen (1967) found that yellowfin tuna (*T. albacares*) can detect sounds from 0.05 to 1.1 kHz, with best sensitivity of 89 dB (re 1 µPa) at 0.5 kHz. Kawakawa (*Euthynnus affinus*) appear to be able to detect sounds from 0.1 to 1.1 kHz but with best sensitivity of 107 dB (re 1 µPa) at 0.5 kHz (Iversen 1969). Additionally, Popper (1981) looked at the inner ear structure of a skipjack tuna (*Katsuwonus pelamis*) and found it to be typical of a hearing generalist. While only a few species of tuna have been studied, and in a number of fish groups both generalists and specialists exist, it is reasonable to suggest that unless bluefin tuna are exposed to very high intensity sounds from which they cannot swim away, short- and long-term effects may be minimal or nonexistent (Song et al. 2006).

Some damselfish have been shown to be able to hear frequencies of up to 2 kHz, with best sensitivity well below 1 kHz. Egner and Mann (2005) found that juvenile sergeant major damselfish (*Abudefduf saxatilis*) were most sensitive to lower frequencies (0.1 to 0.4 kHz); however, larger fish (greater than 50 millimeters [mm]) responded to sounds up to 1.6 kHz. Still, the sergeant major damselfish is considered to have poor sensitivity in comparison even to other hearing generalists (Egner and Mann 2005). Kenyon (1996) studied another marine generalist, the bicolor damselfish (*Stegastes partitus*), and found the bicolor damselfish responded to sounds up to 1.6 kHz with the most sensitive frequency at 0.5 kHz. Further, larval and juvenile Nagasaki damselfish (*Pomacentrus nagasakiensis*) have been found to hear at frequencies between 0.1 and 2 kHz, however, they are most sensitive to frequencies less than 0.3 kHz (Wright et al. 2005, Wright et al. 2007). Thus, damselfish appear to be primarily generalists with some ability to hear slightly higher frequencies expected of specialists (Popper 2008).

Female midshipman fish apparently use the auditory sense to detect and locate vocalizing males during the breeding season. Interestingly, female midshipman fish go through a shift in hearing sensitivity depending on their reproductive status. Reproductive females showed temporal encoding up to 0.34 kHz, while nonreproductive females showed comparable encoding only up to 0.1 kHz (Sisneros and Bass 2003).

The hearing capability of Atlantic salmon (*Samo salar*), a hearing generalist, indicates a rather low sensitivity to sound (Hawkins and Johnstone 1978). Laboratory experiments yielded responses only to 0.58 kHz and only at high sound levels. Salmon's poor hearing is likely due to the lack of a link between the swim bladder and inner ear (Jorgensen et al. 2004).

Furthermore, investigations into the inner ear structure of fishes belonging to the order Scorpaeniformes have suggested that these fishes have generalist hearing abilities (Lovell et al. 2005). Although an audiogram (which provides a measure of hearing sensitivity) has yet to be performed, the lack of a swimbladder is indicative of these species having poor hearing ability (Lovell et al. 2005). However, studies of the leopard robin (*Prionotus scitulus*), another species in this order that do contain swim bladders, indicated that they are hearing generalists as well (Tavolga and Wodinski 1963), which makes extrapolation on hearing from this species to all members of the group very difficult to do (Popper 2008).

3.6.1.5 Current Requirements and Practices

Mitigation measures, implemented for marine mammals and sea turtles, also offer protections to habitats associated with fish communities. Mitigation is discussed in more detail in Chapter 5.

3.6.2 Environmental Consequences

As noted in Section 3.6.1, the ROI for fish is the GOA TMAA, which is more than 12 nm (22 km) from the closest point of land. As such, this section distinguishes between U.S. territorial seas (shoreline to 12 nm) and nonterritorial seas, (seaward of 12 nm) for the purposes of applying the appropriate regulations (National Environmental Policy Act [NEPA] or Executive Order [EO] 12114) to analyze potential environmental effects. Environmental effects in the open ocean beyond the U.S. territorial seas are analyzed in this EIS/OEIS pursuant to EO 12114.

3.6.2.1 Regulatory Framework

The primary laws that make up the regulatory framework for fish and EFH include the MSFCMA and the ESA. These, along with other applicable laws, are briefly described below:

Magnuson-Stevens Fishery Conservation and Management Act

The NPFMC manages the groundfish fisheries, while management of the salmon fisheries is deferred to the State of Alaska. All waters that support anadromous fish are considered EFH by NMFS (NPFMC 2008), while EFH for groundfish varies by species. Federal agencies are required to consult with NMFS and to prepare an EFH Assessment if potential adverse effects on EFH are anticipated from their activities. An EFH Assessment has been prepared for the TMAA.

Sustainable Fisheries Act

In 1996 (later amended in 2002 and 2006), the MSFCMA was reauthorized and amended by the Sustainable Fisheries Act (SFA). The SFA provides a new habitat conservation tool in the form of the EFH mandate. The EFH mandate requires that the regional FMCs, through federal FMP, describe and identify EFH for each federally managed species, minimize to the extent practicable adverse effects on such habitat caused by fishing, and identify other actions to encourage the conservation and enhancement of such habitats. Authority to implement the SFA is given to the Secretary of Commerce through the NMFS. The SFA requires that the EFH be identified and described for each federally managed species. The SFA requires federal agencies to consult with the NMFS on activities that may adversely affect EFH. For actions that affect a threatened or endangered species, its critical habitat, and its EFH, federal agencies must initiate ESA and EFH consultations. Adverse effects mean any impact that reduces quality and/or quantity of EFH. Adverse effects may include direct or indirect physical, chemical, or biological alterations of the waters or substrate and loss of, or injury to, benthic organisms, prey species and their habitat, and other ecosystem components, if such modifications reduce the quality and/or quantity of EFH. Adverse effects to EFH may result from actions occurring within EFH or outside of EFH and may include site-specific or habitat-wide impacts, including individual, cumulative, or synergistic consequences of actions (50 C.F.R. 600.810[a]).

Endangered Species Act

The ESA (16 U.S.C. §§ 1531 to 1543) established protection over and conservation of threatened and endangered species. The ESA applies to federal actions in two separate respects: the ESA requires that federal agencies, in consultation with the responsible wildlife agency, ensure that Proposed Actions are not likely to jeopardize the continued existence of any endangered species or threatened species, or result in the destruction or adverse modification of a critical habitat. Regulations implementing the ESA expand the consultation requirement to include those actions that “may affect” a listed species or adversely modify critical habitat.

If an agency’s Proposed Action would take a listed species, the agency must obtain an incidental take statement from the responsible wildlife agency. The ESA defines the term “take” to mean “harass, harm, pursue, hunt, shoot, wound, kill, trap, capture, or collect, or attempt any such conduct.”

Executive Order 12962

EO 12962 on Recreational Fisheries (60 Federal Register [FR] 30769) was enacted in 1995 to ensure that federal agencies strive to improve the “quantity, function, sustainable productivity, and distribution of U.S. aquatic resources” so that recreational fishing opportunities nationwide can increase. The primary goal of this order is to promote the conservation, restoration, and enhancement of aquatic systems and fish populations by increasing fishing access, education and outreach, and multiagency partnerships. The National Recreational Fisheries Coordination Council, co-chaired by the Secretaries of the Interior and Commerce, is charged with overseeing federal actions and programs that are mandated by this order.

Northern Pacific Halibut Act

The Northern Pacific Halibut Act of 1982 (16 U.S.C. §§ 773-773k) calls for the United States and Canada to implement the 1979 Protocol for the Preservation of the Halibut Fishery of the Northern Pacific Ocean and the Bering Sea. The Act provides for the appointment of U.S. Commissioners to the International Pacific Halibut Commission. In addition, the Act authorizes the NPFMC to develop regulations to limit access and govern the Pacific halibut catch in waters off Alaska. All Council action must be approved and implemented by the U.S. Secretary of Commerce.

National Fishery Enhancement Act

In 1984, Congress passed the National Fishery Enhancement Act (NFEA) (33 U.S.C. §§ 2101 et seq.) in recognition of the social and economic value of artificial reefs in enhancing fishery resources. Under this act, the Secretary of Commerce and the U.S. Army Corps of Engineers are charged with the responsibility for encouraging and regulating artificial reefs in the navigable waters of the United States. One of the primary directives of the NFEA was the preparation of a long-term National Artificial Reef Plan (33 U.S.C. §§ 2103).

Pacific Salmon Treaty

The Pacific Salmon Treaty (PST) of 1985 (16 U.S.C. §§ 3631 et seq.) was established between Canada and the United States to establish a framework for managing salmon populations between the two countries. The Treaty principles were to (a) prevent overfishing and provide for optimum production; and (b) provide equivalent production benefits from salmon originating from the respective country’s waters. The Treaty requires the United States and Canada to meet international conservation and allocation objectives by taking into account ways of reducing interceptions and avoiding disruption of existing fisheries and stock abundances.

This Treaty also called for the establishment of the Pacific Salmon Commission (PSC), to oversee the implementation of the Treaty. The PSC is composed of representatives of both countries to provide regulatory and technical advice. Fisheries regulation is a shared responsibility of the United States and Canada.

On June 30, 1999, the following PST provisions were implemented: (a) establish abundance-based fishing regimes for Pacific salmon fisheries under the jurisdiction of the PSC; (b) create two bilaterally based funds to promote cooperation, improve fishery management, and aid stock and habitat enhancement. Additionally, the PST includes provisions to enhance bilateral cooperation, improve the scientific basis for salmon management, and apply institutional changes to the PSC.

3.6.2.2 Approach to Analysis

This section describes potential environmental effects on fish associated with conducting naval activities for three alternative scenarios in the TMAA. The activities include active sonar activities; surface vessel, submarine, and aircraft warfare training activities; weapons firing; explosives ordnance use; nonexplosives ordnance use; electronic combat; and discharges of expendable materials. These activities are configured in various combinations to define seven warfare areas, as previously described in Chapter 2.

The effects on fish could include direct physical injury, such as potential for death, injury, or failure to (or an increase in the time needed to) reach the next developmental stage. Potential effects on fish eggs, larvae, and adult fish were evaluated in the analysis and results presented in the following subsections. In addition, a review of the literature regarding potential effects on fish common to most activities is presented. These include warfare areas and environmental stressors, acoustic effects of underwater sounds to fish, effects of underwater impulsive sounds, explosive ordnance, nonexplosive ordnance, and expended materials.

Data Sources

A comprehensive and systematic review of relevant literature and data has been conducted in order to complete this analysis for fish and EFH. Of the available scientific literature (both published and unpublished), the following types of documents were utilized in the assessment: journals, books, periodicals, bulletins, Department of Defense (DoD) operations reports, EISs, and other technical reports published by government agencies, private businesses, consulting firms, or nongovernmental conservation organizations. The scientific literature was also consulted during the search for geographic location data on the occurrence of resources within the TMAA. The primary sources of information used to describe the affected environment for fish and EFH was the U.S. Pacific Fleet Marine Resource Assessment (MRA) for the GOA Operating Area (Department of Navy [DoN] 2006). The MRA report provides compilations of the most recent data and information on the occurrence of marine resources in the TMAA.

Assessment Methods

Impact Thresholds

This EIS/OEIS analyzes potential effects to fish and EFH in the context of the MSFCMA (federally managed species and EFH), ESA (species listed under the ESA only), and EO 12114. The factors used to assess the significance of effects vary under these Acts. Pursuant to 50 CFR 600.910(a), an “adverse effect” on EFH is defined as any impact that reduces the quality and/or quantity of EFH (NMFS 2004a, 2004b). To help identify Navy activities that may reduce the quality and/or quantity of EFH and fall within the adverse effect definition, the Navy has determined that temporary or minimal impacts are not considered to “adversely affect” EFH. The MSFCMA EFH regulations (50 CFR 600.815[a][2][ii]) and the EFH Final Rule (67 Fed. Reg. 2354) were used as guidance for this determination, as they highlight activities with impacts that are more than minimal and not temporary in nature, as opposed to those activities resulting in inconsequential changes to habitat[1]. Temporary effects are those that are limited in duration and allow the particular environment to recover without measurable impact (67 Fed. Reg. 2354). Minimal effects are those that may result in relatively small changes in the affected environment and insignificant changes in ecological functions (67 Fed. Reg. 2354). Whether an impact is minimal depends on a number of factors[2]:

- The intensity of the impact at the specific site being affected;
- The spatial extent of the impact relative to the availability of the habitat type affected;
- The sensitivity/vulnerability of the habitat to the impact;
- The habitat functions that may be altered by the impact (e.g., shelter from predators); and

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[1] While the “more than minimal and not temporary” criteria referenced in the EFH regulations is specific to assessing impacts on EFH from fishing activities, in the absence of similar guidance/criteria for assessing nonfishing impacts on EFH, the same criteria will be used for determining whether Navy’s non-fishing impacts reduce the quality and/or quantity of EFH.

[2] NMFS. 2002. Considerations for Conducting a Thorough Analysis of Options to Minimize the Adverse Effects of Fishing on EFH. Available at:
http://www.nmfs.noaa.gov/habitat/habitatprotection/pdf/efh/fishmgmt/fishing_impacts_considerations_final.pdf

- The timing of the impact relative to when the species or life stage needs the habitat.

The factors outlined above were also considered in determining the significance of effects under EO 12114. For purposes of ESA compliance, effects of the action were analyzed to make the Navy's determination of effect for listed species. The definitions used in making the determination of effect under Section 7 of the ESA are based on the USFWS and NMFS *Endangered Species Consultation Handbook* (USFWS 1998).

Warfare Areas and Associated Environmental Stressors

The Navy used a screening process to identify aspects of the Proposed Action that could act as stressors to fish and EFH. Navy subject matter experts de-constructed the warfare areas and activities included in the Proposed Action to identify specific activities that could act as stressors. Public and agency scoping comments, previous environmental analyses, previous agency consultations, laws, regulations, EOs, and resource-specific information were also evaluated. This process was used to focus the information presented and analyzed in the affected environment and environmental consequences sections of this EIS/OEIS. Potential stressors to fish and EFH include vessel movements (disturbance and collisions), aircraft overflights (disturbance), explosive ordnance, sonar training (disturbance), weapons firing/nonexplosive ordnance use (disturbance and strikes), and expended materials (ordnance-related materials, targets, sonobuoys, and marine markers).

Acoustic Effects of Underwater Sounds to Fish

There have been very few studies on the effects that human-generated sound may have on fish; these have been reviewed in a number of places (e.g., NRC, 1994, 2003, Popper 2003, Popper et al. 2004, Hastings and Popper 2005, Popper 2008, Popper and Hastings 2009), and some more recent experimental studies have provided additional insight into the issues (e.g., Doksæter et al. 2009, Govoni et al. 2003, McCauley et al. 2003, Popper et al. 2005, 2007). Most investigations, however, have been in the gray literature (non peer-reviewed reports – see Hastings and Popper 2005, Popper 2008, and Popper and Hastings 2009) for extensive critical reviews of this material). While some of these studies provide insight into effects of sound on fish, the majority of the gray literature studies often lack appropriate controls, statistical rigor, and/or expert analysis of the results.

There are a wide range of potential effects on fish that range from no effect at all (e.g., the fish does not detect the sound or it "ignores" the sound) to immediate mortality. In between these extremes are a range of potential effects that parallel the potential effects on marine mammals that were illustrated by Richardson et al. (1995). These include, but may not be limited to:

- No effect behaviorally or physiologically: The animal may not detect the signal, or the signal is not one that would elicit any response from the fish.
- Small and inconsequential behavioral effects: Fish may show a temporary "awareness" of the presence of the sound but soon return to normal activities.
- Behavioral changes that result in the fish moving from its current site: This may involve leaving a feeding or breeding ground. Some behavioral changes can result in lost feeding or reproduction opportunities, or make fish vulnerable to other stressors in the environment such as the presence of predators. This effect may be temporary, in that the fish return to the site after some period of time (perhaps after a period of acclimation or when the sound terminates), or permanent.
- Temporary loss of hearing (often called Temporary Threshold Shift – TTS): This recovers over minutes, hours, or days.

- Physical damage to auditory or nonauditory tissues (e.g., swim bladder, blood vessels, brain): The damage may be only temporary, and the tissue "heals" with little impact on fish survival, or it may be more long term, permanent, or may result in death. Death from physical damage could be a direct effect of the tissue damage or the result of the fish being more subject to predation than a healthy individual.

Studies on effects on hearing have generally been of two types. In one set of studies, the investigators exposed fish to long-term increases in background sound to determine if there are changes in hearing, growth, or survival of the fish. While data are limited to a few freshwater species, it appears that some increase in ambient sound level, even to above 170 dB re 1 μPa, does not permanently alter the hearing ability of the hearing generalist species studied, even if the increase in sound level is for an extended period of time. However, this may not be the case for all hearing generalists, though it is likely that any temporary hearing loss in such species would be considerably less than for specialists receiving the same sound exposure. It is critical to note that more extensive data are needed on additional species, and if there are places where the ambient levels exceed 170 to 180 dB, it would be important to do a quantitative study of effects of long-term sound exposure at these levels. It is also clear that there is a larger temporary hearing loss in hearing specialists. Again, however, extrapolation from the few freshwater species to other species (freshwater or marine) must be done with caution until there are data for a wider range of species, and especially species with other types of hearing specializations than those found in the species studied to date (all of which are otophysan fishes and have the same specializations to enhance hearing).

In the second type of studies, fish were exposed to short duration but high intensity signals such as might be found near a high intensity sonar, pile driving, or seismic air gun survey. The investigators in such studies were examining whether there was not only hearing loss and other long-term effects, but also short-term effects that could result in death to the exposed fish. Because study results vary, it is difficult to speculate why there are many differences in the studies, including species, precise sound source, and spectrum of the sound (Popper 2008, Popper and Hastings 2009).

One study tested effects of seismic air guns, a highly impulsive and intense sound source. This study demonstrated differences in the effects of air guns on the hearing thresholds of different species. In effect, these results substantiate the argument made by Hastings et al. (1996) and McCauley et al. (2003) that it is difficult to extrapolate between species with regard to the effects of intense sounds.

Another study examined the effects of Surveillance Towed Array Sensor System Low-Frequency Active (SURTASS LFA) sonar; this study determined there was no effect on ear tissue (Popper et al. 2007).

Other earlier studies suggested that there may be some loss of sensory hair cells due to high intensity sources. However, these studies did not concurrently investigate effects on hearing or nonauditory tissues (Enger 1981, Hastings et al. 1996). In neither study was the hair cell loss more than a relatively small percent of the total sensory hair cells in the hearing organs (Popper 2008).

Effects of Underwater Impulsive Sounds

Air gun studies on very few species resulted in a small hearing loss in several species, with complete recovery within 18 hours (Popper et al. 2005). Other species showed no hearing loss with the same exposure. There appeared to be no effects on the structure of the ear, and a limited examination of nonauditory tissues, including the swim bladder, showed no apparent damage (Popper et al. 2005). One other study of effects of an air gun exposure showed some damage to the sensory cells of the ear (McCauley et al. 2003); it is difficult to differentiate these two studies. However, the two studies employed different methods of exposing fish, and used different species. Other studies have demonstrated some behavioral effects on fish during air gun exposure used in seismic exploration (e.g., Pearson et al.

1987, 1992, Engås et al. 1996, Engås and Løkkeborg 2002, Slotte et al. 2004), but the data are limited and it would be very difficult to extrapolate to other species, as well as to other sound sources.

Explosive Sources

A number of studies have examined the effects of explosives on fish; these are reviewed in detail in Hastings and Popper (2005). However, these studies are often variable, so extrapolation from one study to another, or to other sources, such as those used by the Navy, is not really possible. While many of these studies show that fish are killed if they are near the source, and there are some suggestions that there is a correlation between size of the fish and death (Yelverton et al. 1975), little is known about the very important issues of nonmortality damage in the short- and long-term, and nothing is known about effects on behavior of fish.

The major issue in explosives is that the gas oscillations induced in the swim bladder or other air bubble in fishes caused by high sound pressure levels can potentially result in tearing or rupturing of the chamber. This has been suggested to occur in some (but not all) species in several gray literature unpublished reports on effects of explosives (e.g., Aplin 1947, Coker and Hollis 1950, Gaspin 1975, Yelverton et al. 1975), whereas other published studies do not show such rupture (e.g., the peer reviewed study by Govoni et al. 2003). Key variables that appear to control the physical interaction of sound with fishes include the size of the fish relative to the wavelength of sound, mass of the fish, anatomical variation, and location of the fish in the water column relative to the sound source (e.g., Yelverton et al. 1975, Govoni et al. 2003).

Explosive blast pressure waves consist of an extremely high peak pressure with very rapid rise times (< 1 millisecond [ms]). Yelverton et al. (1975) exposed eight different species of freshwater fish to blasts of 1-pound (lb) spheres of Pentolite (high explosive) in an artificial pond. The test specimens ranged from 0.02 grams (g) (guppy) to 744 g (large carp) body mass and included small and large animals from each species. The fish were exposed to blasts having extremely high peak overpressures with varying impulse lengths. The investigators found what appears to be a direct correlation between body mass and the magnitude of the "impulse," characterized by the product of peak overpressure and the time it took the overpressure to rise and fall back to zero (units in pounds per square inch (psi)-ms), which caused 50 percent mortality (see Hastings and Popper 2005 for detailed analysis).

One issue raised by Yelverton et al. (1975) was whether there was a difference in lethality between fish which have their swim bladders connected by a duct to the gut and fish which do not have such an opening. The issue is that it is possible that a fish with such a connection could rapidly release gas from the swim bladder on compression, thereby not increasing its internal pressure. However, Yelverton et al. (1975) found no correlation between lethal effects on fish and the presence or lack of connection to the gut.

While these data suggest that fishes with both types of swim bladders are affected in the same way by explosive blasts, this may not be the case for other types of sounds, and especially those with longer rise or fall times that would allow time for a biomechanical response of the swim bladder (Hastings and Popper 2005). Moreover, there is some evidence that the effects of explosives on fishes without a swim bladder are less than those on fishes with a swim bladder (e.g., Gaspin 1975, Goertner et al. 1994, Keevin et al. 1997). Thus, if internal damage is, even in part, an indirect result of swim bladder (or other air bubble) damage, fishes without this organ may show very different secondary effects after exposure to high sound pressure levels. Still, it must be understood that the data on effects of impulsive sources and explosives on fish are limited in number and quality of the studies, and in the diversity of fish species studied. Thus, extrapolation from the few studies available to other species or other devices must be done with the utmost caution.

In a more recent published report, Govoni et al. (2003) found damage to a number of organs in juvenile pinfish (*Lagodon rhomboids*) and spot (*Leiostomus xanthurus*) when they were exposed to underwater detonations at a distance of 11.8 ft (3.6 m), and most of the effects, according to the authors, were sublethal. Effects on other organ systems that would be considered irreversible (and presumably lethal) only occurred in a small percentage of fish exposed to the explosives. Moreover, there was virtually no effect on the same sized animals when they were at a distance of 24.6 ft (7.5 m), and more pinfish than spot were affected.

Based upon currently available data it is not possible to predict specific effects of Navy impulsive sources on fish. At the same time, there are several results that are at least suggestive of potential effects that result in death or damage. First, there are data from impulsive sources such as pile driving and seismic air guns that indicate that any mortality declines with distance, presumably because of lower signal levels. Second, there is also evidence from studies of explosives (Yelverton et al. 1975) that smaller animals are more affected than larger animals. Finally, there is also some evidence that fish without an air bubble, such as flatfish and sharks and rays, are less likely to be affected by explosives and other sources than are fish with a swim bladder or other air bubble.

Yet, as indicated for other sources, the evidence of short- and long-term behavioral effects, as defined by changes in fish movement, etc., is nonexistent. Thus, it is unknown if the presence of an explosion or an impulsive source at some distance, while not physically harming a fish, will alter its behavior in any significant way.

Expended Materials

Falling Material and Small-Arms Rounds

Inert bombs, intact missiles, and targets could impact the water with great force and produce a large impulse and loud sound. Physical disruption of the water column by the shock wave and bubble pulse is a localized, temporary effect, and would be limited to within tens of meters of the impact area and would persist for a matter of minutes. Large objects hitting the water produce sounds with source levels on the order of 240 to 271 dB re 1 μPa and pulse durations of 0.1 to 2 ms, depending on the size of the object (McLennan 1997). Physical and chemical properties of seawater would be temporarily affected (e.g., increased oxygen concentrations due to turbulent mixing with the atmosphere), but there would be no lasting adverse effect on the water column habitat from this physical disruption. Given the size of the TMAA, the infrequency of the activities, and the distribution of fish species, a remote possibility exists that some individual fish at or near the surface may be directly impacted (i.e., direct strike) if they are in the target area at the point of physical impact at the time of nonexplosive ordnance delivery. Therefore, effects of shock waves from inert bombs and intact missiles and targets hitting the water surface on fish are expected to be localized and minimal.

However, most missiles hit their target or are disabled before hitting the water. Thus, most of these missiles and aerial targets hit the water as fragments, which quickly dissipate their kinetic energy within a short distance from the surface. Similarly, expended small-arms rounds may also strike the water surface with sufficient force to cause injury. Most fish swim some distance below the surface of the water. Therefore, fewer fish are exposed to mortality from falling fragments whose effects are limited to the near surface, than mortality from intact missiles and targets whose effects can extend well below the water surface.

Munitions Constituents

Munitions constituents can be released from sonobuoys, targets, torpedoes, missiles, aerial targets, and at sea explosions. Petroleum hydrocarbons released during an accident are harmful to fish. Jet fuel is toxic to fish but floats and vaporizes very quickly. Assuming that a target disintegrates on contact with the water, any residual unburned fuel may be spread over a large area and dissipate quickly. In addition, fuel spills and material released from weapons and targets could occur at different locations and at different times.

Potential impacts from Navy explosives training include degradation of substrate and introduction of toxic chemicals into the water column. Combustion products from the detonation of high explosives—carbon monoxide (CO), carbon dioxide (CO_2), hydrogen (H_2), water (H_2O), nitrogen (N_2), and ammonia (NH_3)—are commonly found in sea water. The primary constituents that would be released from explosives training are nitroaromatic compounds such as trinitrotoluene (TNT), cyclonite (Royal Demolition Explosive or RDX), and octogen (High Melting Explosive or HMX) (URS 2000). Initial concentrations of explosion by-products are not expected to be hazardous to marine life (DoN 2001) and would not accumulate in the training area because exercises are spread out over time and the chemicals disperse in the ocean. The water quality effects of the explosions would be infrequent, temporary, and localized, and would have no long-term adverse effect on water quality. Effects on marine fish associated with the release of munitions constituents and other materials are expected to be minimal.

3.6.2.3 No Action Alternative

Under the No Action Alternative, baseline levels of activities would remain unchanged from current conditions. Fish would have the potential to be affected by vessel movement, aircraft overflights, explosive ordnance, nonexplosive ordnance use, weapons firing disturbance, and expended materials.

Vessel Movements

Many of the ongoing and proposed activities within the TMAA involve maneuvers by various types of surface vessels, most of which use propellers for propulsion. When moving, vessels generally displace water from the hull, and an even greater volume from propeller wash. Currently, approximately four Navy vessels will be operating in the TMAA, but the number can vary based on training schedules and scenarios. Activities involving vessel movements occur intermittently and are short in duration, generally a few hours in duration. These activities are widely dispersed throughout the TMAA, which is a vast area encompassing 42,146 square nm (nm^2) (144,557 square km [km^2]) of surface/subsurface ocean.

Vessel movements have the potential to expose fish to sound and general disturbance, which could result in short-term behavioral and/or physiological responses (swimming away, increased heart rate). Such responses would not be expected to compromise the general health or condition of individual fish. The probability of collisions between vessels and adult fish, which could result in injury or mortality, would be extremely low because this life stage is highly mobile and Navy vessel density in the TMAA is low. Vessel movements would result in short-term and localized disturbances to the water column, but benthic habitats would not be affected. Ichthyoplankton (fish eggs and larvae) in the upper portions of the water column could be displaced, injured, or killed by vessel and propeller movements. However, no measurable effects on fish recruitment would occur because the number of eggs and larvae exposed to vessel movements would be low relative to total ichthyoplankton biomass. Vessel movements under the No Action Alternative would not result in adverse effects to fish populations or EFH as defined under the MSFCMA. In accordance with EO 11214, harm to fish populations or habitat from vessel movements in nonterritorial seas would be minimal under the No Action Alternative.

Aircraft Overflights

Aircraft overflights produce airborne sound and some of this energy would be transmitted into the water. However, sound does not transmit well from air to water. Predicted sound levels resulting from HC-130 aircraft flying at 1,000 ft (305 m) and 250 ft (76 m) were 110 and 121 dB re 1 μPa, respectively, directly under the flight path at a depth of 1 ft (maximum one-third octave level for frequencies 20 hertz [Hz]–5 kHz). The same sound levels resulting from an HH-60 helicopter flying at 1,000 ft (305 m), flying at 100 ft (30 m), and hovering 10 ft (3 m) were 110, 129, and 143 dB re 1 μPa (respectively) directly under the helicopter at a depth of 1 ft (0.3 m) (USAF 1999). The sound levels would decline at increasing lateral distances from the aircraft's track or location and with increasing depth in the water, and the underwater sounds originating from the aircraft would decline rapidly after the aircraft has passed. It is unlikely that these sound levels would cause physical damage or even behavioral effects in fish based on the sound levels that have been found to cause such effects. In addition to sound, helicopters flying at low levels can create a vertical down wash of air (rotor wash) that becomes a surface wind, which may disturb the water surface below the aircraft and displace any fishes in the general vicinity.

Such responses would not compromise the general health or condition of individual fish. Aircraft overflights under the No Action Alternative would not result in adverse effects to fish populations or EFH as defined under MSFCMA. In accordance with EO 11214, harm to fish populations or habitat from aircraft overflight movements in nonterritorial seas under the No Action Alternative would be minimal.

Explosive Ordnance

Explosions that occur under the No Action Alternative in the TMAA are associated with training exercises that use explosive ordnance, including bombs (BOMBEX), missiles (MISSILEX), and naval gun shells (GUNEX), 5-inch (in) high explosive rounds (see Table 3.6-8 for number of explosive ordnance expended annually for all Alternatives). Potential effects of explosive charge detonations on fish and EFH include disruption of habitat; exposure to chemical by-products; disturbance, injury, or death from the shock (pressure) wave; acoustic impacts; and indirect effects including those on prey species and other components of the food web.

Concern about potential fish mortality associated with the use of at-sea explosives led military researchers to develop mathematical and computer models that predict safe ranges for fish and other animals from explosions of various sizes (e.g., Yelverton et al. 1975, Goertner 1982, Goertner et al. 1994). Young's (1991) equations for 90-percent survivability were used to estimate fish mortality in the Seawolf Shipshock Trial EIS (DoN 1998). In that document, Yelverton's (1981) equations were used to predict survival of fish with swim bladders, although the equations apply to simple explosives, and may not apply to all the explosives used in the TMAA. The impulse levels that kill or damage fish with swim bladders have been determined empirically to be as follows (from Yelverton 1981):

- 50 percent Mortality $\ln(I)=3.6136 + 0.3201 \ln(M)$
- 1 percent Mortality $\ln(I)=3.0158 + 0.3201 \ln(M)$
- No Injuries $\ln(I)=2.0042 + 0.3201 \ln(M)$

Where I = impulse (in Pascal•seconds or Pa•s) and M = body mass of a fish (g) with a swim bladder.

Yelverton (1981) cautioned against using these equations for fish weighing more than a few kg because fish used in the experiments from which these equations were derived did not weigh more than 2.2 lb (1 kg). Young's parameters include the size of the fish and its location relative to the explosive source, but are independent of environmental conditions (e.g., depth of fish and explosive shot frequency). An example of such model predictions is shown in Table 3.6-5, which provides the radius of effect of various charges, depths, and fish size. The 10-percent mortality range is the distance beyond which 90 percent of the fish present would be expected to survive.

Table 3.6-5: Range of Effects for at-Sea Explosions

Charge	Charge Depth	Effect Criterion	Range of Effect
1 lb	9.8 ft (3.0 m)	10% Mortality	338 ft (103 m) for 1-ounce fish 180 ft (55 m) for 1-pound. fish 89 ft (27 m) for 30-pound fish
10 lbs	125 ft (38 m)	10% Mortality	656 ft (200 m) for 1-ounce fish 423 ft (129 m)s for 1-pound fish 259 ft (79 m) for 30-pound fish
20 lbs	62 ft (19 m)	10% Mortality	856 ft (261 m) for 1-ounce fish 554 ft (169 m) for 1-pound fish 348 ft (106 m) for 30-pound fish
20 lbs	125 ft (38 m)	10% Mortality	928 ft (283 m) for 1-ounce fish 597 ft (182 m) for 1-pound fish 364 ft (111 m) for 30-pound fish

Typically, BOMBEX at sea involve one or more aircraft bombing a target simulating a hostile surface vessel. Practice bombs entering the water would be devoid of combustion chemicals found in the warheads of explosive bombs, and would generate physical shock entering the water, but would not explode. After sinking to the bottom, the physical structure of bombs would be incorporated into the marine environment by natural encrustation and/or sedimentation (discussed later in Expended Materials Section). Air-to-ground bombing using explosive ordnance is mostly conducted on land ranges which are outside the scope of the ROI; however, some live bombs may be dropped at sea (see Table 3.6-8 for number of explosive ordnance expended annually for all Alternatives).

As with underwater detonations, the range within which fish may sustain injury or death from an exploding bomb would depend on environmental parameters, the size, location, and species of the fish, and its internal anatomy (e.g., whether it has a swim bladder) (DoN 2005). Fish without swim bladders are far more resistant to explosions than those with swim bladders (Keevin and Hempen 1997). Explosive bombs will be fused to detonate on contact with the water and it is estimated that 99 percent of them will explode within 5 ft (1.5 m) of the ocean surface (DoN 2005). Table 3.6-6, based on Young's (1991) model, displays 10-percent mortality (90-percent survival) ranges for the largest explosive bombs that may be deployed during at-sea exercises.

Table 3.6-6: Estimated Fish-Effects Ranges for Explosive Bombs

Warhead Weight NEW (lb-TNT)	10% Mortality Range by Weight of Fish		
	1 ounce	1 pound	30 pounds
500 lbs	1,289 ft (393 m)	899 ft (274 m)	578 ft (176 m)
1,000 lbs	1,343 ft (409 m)	937 ft (286 m)	602 ft (184 m)
2,000 lbs	1,900 ft (579 m)	1,325 ft (404 m)	852 ft (260 m)

Note: NEW = Net Explosive Weight

Potential effects from the use of Naval gun systems have been analyzed in a variety of environmental documents (DoN 2000, 2001b, 2002, 2004, 2007). The 5-inch gun has the largest warhead fired during routine gunnery exercises. Most training uses nonexplosive 5-in rounds. The surface area of the ocean impacted by a nonexplosive 5-in round has been estimated to be 20 square in (in^2) (129 square cm [cm^2]) (DoN 2007). Considering the vast expanse of the TMAA, few fish would be directly struck by a shell from a 5-in gun.

Explosive rounds would have the greatest potential for impacts to fish in surface waters. As previously indicated, biological effects of at sea explosions depend on many factors, including the size, type, and depth of both the animal and the explosive, the depth of the water column, the standoff distance from the charge to the animal, and the sound-propagation properties of the environment. Potential impacts can range from brief acoustic effects, tactile perception, and physical discomfort, to slight injury to internal organs and the auditory system, to death of the animal (Keevin and Hempen 1997).

Table 3.6-7 provides an estimation of the potential range of lethal effects on swim bladder fish based on Young's (1991) model for five-in explosive projectiles. These rounds have a Net Explosive Weight (NEW) of TNT of approximately 8 lb (3.6 kg) and are assumed to detonate at a depth of 5 ft (1.3 m). Behavioral reactions of fish would extend over a substantially larger area. The overall impacts to water-column habitat would, however, be minor as fish would return following the activity. The abundance and diversity of fish and the quality and quantity of fish habitat within the range is unlikely to decrease as a result of gun fire training.

Table 3.6-7: Estimated Fish-Effects Ranges for 5-in Naval Gunfire Rounds

Weight of Fish	10% Mortality Range	
	feet	meters
1 ounce (28 g)	405	123
1 lb (0.4 kg)	282	86
30 lbs (13.6 kg)	181	55

Impacts to fish under the No Action Alternative from explosions would be possible, but these elements of the action are not expected to have measurable or detectable impacts to fish given the vast area encompassing the TMAA (42,146 nm^2 [144,557 km^2]); further reduced using conservative estimates assuming that activities occur across 20 percent of the TMAA (Table 3.6-8). While serious injury and/or mortality to individual fish would be expected if they were present in the immediate vicinity of explosive ordnance use, explosions under the No Action Alternative would not result in impacts to fish populations based on the low number of fish, in relation to the size of the population that would be affected. Disturbances to the water column would be short-term and localized, while disturbance to benthic habitats from explosions would be unlikely due to the water depth where training activities occur. Habitat disturbance and fish injury and mortality from explosions are reduced by Navy mitigation measures, as discussed in Chapter 5. Explosive ordnance under the No Action Alternative would not result in adverse effects to fish populations or EFH as defined under MSFCMA. In accordance with EO 11214, harm to fish populations or habitat from explosive ordnance use in nonterritorial seas would be minimal under the No Action Alternative.

Weapons Firing Disturbance

When a gun is fired from a surface ship, a blast wave propagates away from the gun muzzle. When the blast wave meets the water, most of the energy is reflected back into the air, but some energy is transmitted into the water. A series of pressure measurements were taken during the firing of a 5-in gun aboard the *USS Cole* in June 2000 (Dahlgren 2000). The average peak pressure measured was about 200 dB re 1 µPa at the point of the air and water interface. Down-range peak pressure level, estimated for spherical spreading of the sound in water**,** would be 160 dB re 1 µPa at 328 ft (100 m) and 185 dB re 1 µPa at ~18 ft (5.5 m). The resulting ensonified areas (semi-circles with radius 328 ft [100 m] and 18 ft [5.5 m]) would be 0.004 nm^2 (0.015 km^2) and ~60 yd^2 (50 m^2), respectively.

Table 3.6-8: Number of Explosive Ordnance Expended Annually in 20% of the TMAA for the No Action Alternative, Alternative 1, and Alternative 2

Ordnance	No Action Alternative		Alternative 1			Alternative 2		
	Number	Number per nm^2 (km^2)*	Number	% Increase from No Action	Number per nm^2 (km^2)*	Number	% Increase from No Action	Number per nm^2 (km^2)*
Bombs	48	0.006 (0.002)	72	50%	0.009 (0.002)	166	246%	0.017 (0.005)
Naval Gunshells (5-inch/76 mm)	40	0.005 (0.001)	56	40%	0.007 (0.002)	112	180%	0.013 (0.004)
IEER Sonobuoys	0	0	40	NA	0.005 (0.001)	80	NA	0.009 (0.003)
SINKEX	0	0	0	NA	0	858	NA	0.102 (0.030)
Total	**88**	0.010 (0.003)	**168**	**91%**	0.020 (0.006)	**1,194**	**1,257%**	0.142 (0.041)

*Total may vary due to rounding.

Because effects to fish can occur from impulsive sounds greater than 180 dB (Popper et al. 2005), only those in the immediate vicinity (0.004 nm^2 [0.015 km^2] area) would be affected and effects would be limited to short-term, transitory alarm or startle responses. Since activities are infrequent (see Table 3.6-8) and widely dispersed throughout the TMAA, weapons firing under the No Action Alternative would not result in adverse effects to fish populations or EFH as defined under the MSFCMA. Furthermore, harm to fish populations or habitat from weapons firing disturbance movements in nonterritorial seas would be minimal in accordance with EO 11214.

Expended Materials

The Navy uses a variety of expended materials during training exercises conducted in the TMAA. The types and quantities of expended materials used and information regarding fate and transport of these materials within the marine environment are summarized in Table 3.6-9, and are discussed in Sections 3.2 (Expended Materials) and 3.3 (Water Resources). The analyses presented in these sections predict that the majority of the expended materials would rapidly sink to the sea floor, become encrusted by natural processes, and incorporated into the sea floor, with no significant accumulations in any particular area and no significant negative effects to water quality or marine benthic communities.

Nonexplosive Ordnance

Current Navy training activities in the TMAA such as MISSILEX, BOMBEX, and GUNEX include firing a variety of weapons and employ a variety of nonexplosive training rounds, including bombs, naval gun shells, cannon shells, and small caliber ammunition. These materials are used in the TMAA located in the open ocean beyond 20 nm (37 km). Direct ordnance strikes from firing weapons are potential stressors to fish.

Table 3.6-9: Expended Training Materials in the TMAA – All Alternatives

	No Action Alternative	Alternative 1		Alternative 2	
Training Material	**Number**	**Number**	**% Increase from No Action**	**Number**	**% Increase from No Action**
Bombs	120	180	50%	360	200%
Missiles	22	33	50%	66	200%
Targets and Pyrotechnics	252	322	28%	644	160%
Naval Gunshells	10,564	13,188	25%	26,376	150%
Small Caliber Rounds	5,000	5,700	14%	11,400	128%
Sonobuoys	24	793	3,204%	1,587	6,513%
PUTR	0	7	NA	7	NA
SINKEX	0	0	NA	858	NA
Total	**15,982**	**20,223**	**26%**	**41,298**	**160%**
Number per nm^2 (km^2) within 20% of TMAA	**1.9 (0.5)**	**2.4 (0.7)**		**4.9 (1.4)**	

Nonexplosive bombs and intact targets could impact the water with great force and produce a large impulse and loud sound. Physical disruption of the water column by the shock wave and bubble pulse is a localized, temporary effect, and would be limited to within tens of meters of the impact area and persist for a matter of minutes. Physical and chemical properties would be temporarily affected (e.g., increased oxygen concentrations due to turbulent mixing with the atmosphere), but there would be no lasting adverse effect on the water column habitat from this physical disruption.

Large objects hitting the water produce sounds with source levels on the order of 240 to 271 dB re 1 µPa and pulse durations of 0.1 to 2 ms, depending on the size of the object (McLennan 1997). Impulses of this magnitude could potentially injure fish. Because the rise times of these shock waves are very short, the impulses causing injury and mortality derived for explosive sources were used to estimate effects of shock pulses created by missile and target effects.

While serious injury and/or mortality to individual fish would be expected if they were present in the immediate vicinity of a nonexplosive ordnance use, under the No Action Alternative, the total number of nonexplosive ordnance in the TMAA would be 15,770 items per year. Based on a TMAA size of 42,146 nm^2 (144,557 km^2) and conservatively assuming that activities occur across 20 percent of the TMAA, the concentration of expended ordnance would be 1.9 per nm^2 (0.5 per km^2). More than 97 percent of these items would be from gunshells and small caliber rounds. Based on the low density of use, nonexplosive ordnance use would not result in significant impacts to fish populations. Disturbances to the water column would be short-term and localized, while disturbance to benthic habitats would be unlikely due to the water depth where training activities are proposed. Nonexplosive ordnance use under the No Action Alternative would not result in adverse effects to fish populations or EFH as defined under the MSFCMA. Harm to fish populations or habitat from nonexplosive ordnance use in nonterritorial seas would be minimal in accordance with EO 11214.

The probability of fish ingesting expended ordnance would depend on factors such as the location of the spent materials, size of the materials, and the level of benthic foraging that occurs in the impact area, which is a function of benthic habitat quality, prey availability, and species-specific foraging strategies. It is possible that persistent expended ordnance could be colonized by benthic organisms, and mistaken for prey, or that expended ordnance could be accidentally ingested while foraging for natural prey items. As discussed in Section 3.2, no long-term impacts to water or sediment quality are anticipated from ordnance-related materials.

Ingestion of expended ordnance may affect individual fish; however, ordnance-related expended materials under the No Action Alternative would not result in adverse effects to fish populations or EFH as defined under the MSFCMA. Harm to fish populations or habitat from ordnance-related materials in nonterritorial seas would be minimal in accordance with EO 11214 under the No Action Alternative.

Target Related Materials

A variety of at-sea targets would be used in the TMAA, ranging from high-tech remotely operated airborne and surface targets (such as airborne drones) to low-tech floating at-sea targets (such as inflatable targets) and airborne towed banners. Many of the targets are designed to be recovered for reuse and are not destroyed during training. Under the No Action Alternative, LUU-2B/B illuminating flares, Tactical Air Launched Decoys (TALDs), BQM-74E unmanned aircraft, and MK-58 marine markers will not be recovered, resulting in approximately 1.53 tons (1,388 kg) of expended training materials.

Illuminating flares and marine markers are consumed during use. Smoke from marine markers rapidly diffuses by air movement. The MK-58 marine marker is approximately 2 ft (0.6 m) in length, and sinks to the bottom intact; these targets present no ingestion hazard to fish. It produces chemical flames and regions of surface smoke and are used in various training exercises to mark a surface position to simulate divers, ships, and points of contact on the surface of the ocean. The smoke dissipates in the air, having little effect on the marine environment. The marker itself is not designed to be recovered, and will eventually sink to the bottom and become encrusted or incorporated into the sediments. Phosphorus contained in the marker settles to the sea floor, where it reacts with the water to produce phosphoric acid until all phosphorus is consumed. Combustion of red phosphorus produces phosphorus oxides, which have a low toxicity to aquatic organisms. Red phosphorus released during training is not anticipated to substantially affect the marine environment (DoN 2006). Approximately 20 marine markers would be used in the TMAA under the No Action Alternative. Given the size of the TMAA and the low number of markers used, it would be very unlikely that fish would be affected by use of marine markers.

Under the No Action Alternative, eight TALDs would be used annually. TALDs operate as an expendable vehicle with no recovery capabilities, and use lithium sulfur dioxide batteries. An important component of the thermal battery is a hermetically-sealed casing of welded stainless steel 0.03- to 0.1-in thick that is resistant to the battery electrolytes. As discussed in Section 3.2, in the evaluation of the potential effects associated with seawater batteries, it is expected that in the marine environment, lithium potentially released from these batteries would be essentially nontoxic in seawater. Because of these factors, lithium batteries would not adversely affect fish.

The TALD will not result in any significant physical impacts to the sea floor, as it is unlikely that it would remain intact upon contact with the water. Therefore, small sections would be dispersed by currents prior to settling to the bottom. These pieces would sink into a soft bottom or would lie on a hard bottom, where they may provide a substrate for benthic colonization or eventually be covered by shifting sediments. Metal components are corroded by seawater at slow rates. Natural encrustation of exposed surfaces would eventually occur as invertebrates grow on the surfaces of the sunken objects. As the exterior becomes progressively more encrusted, the rates at which the metals will dissolve into the surrounding water will also decrease. Rates of deterioration would vary, depending on material and conditions in the immediate marine and benthic environment. Factors such as oxygen content, salinity, temperature, and pH all contribute to the manner and speed at which metals will dissolve. Over a period of years, the TALDs would degrade, corrode, and become encrusted or incorporated into the sediments, thus precluding adverse effects to fish.

The BQM-74E is a remote-controlled, subsonic, jet-powered aerial target that can be launched from the air or surface and recovered on land or at sea. It is powered by a jet engine, and thus contains oils, hydraulic fluid, batteries, and explosive cartridges. The hazardous materials of concern include propellant, petroleum products, metals, and batteries; however, the hazardous materials in aerial targets would be mostly consumed during training use.

As discussed in Section 3.2, expended seawater-activated batteries will not have a substantial impact to the environment because chemical reactions in batteries continue until battery life ends, with only a small amount of reactants remaining. Remaining chemicals will leach slowly, and will be diluted by ocean and tidal currents. Also discussed in Section 3.2, most target fragments will sink quickly in the sea. Expended material that sinks to the sea floor would gradually degrade, be overgrown by marine life, or be incorporated into bottom sediments.

Chaff

Chaff consists of aluminum-coated polymer fibers inside of a launching mechanism. Upon deployment, the chaff and small pieces of plastic are expended. Chaff may be deployed mechanically or pyrotechnically. Mechanical deployment results in expended paper materials, along with the chaff. Pyrotechnic deployment uses a small explosive cartridge to eject the chaff from a small tube. Chaff fibers are widely dispersed on deployment. Chaff settling on the ocean surface may temporarily raise turbidity, but will quickly disperse with particles eventually settling to the ocean floor.

An extensive review of literature, combined with controlled experiments, revealed that chaff use pose little risk to the environment or animals (U.S. Air Force 1997, Naval Research Laboratory 1999). The materials in chaff are generally nontoxic except in quantities significantly larger than those any marine fish could reasonably be exposed to from normal usage. Particulate tests and a screening health risk assessment concluded that the concern about chaff breaking down into respirable particle sizes is not a significant issue. Experiments have shown that animals should not suffer toxic or physical effects from chaff ingestion (U.S. Air Force 1997, Naval Research Laboratory 1999). There is no published evidence that chaff exposure has caused the death of a marine fish, and experiments have shown no direct effects of chaff on marine animals (U.S. Air Force 1997, Naval Research Laboratory 1999), therefore no effects of chaff on fish are expected.

Sonobuoys

Under the No Action Alternative, 24 SSQ-36 Bathythermograph (BT) sonobuoys will be expended. The SSQ-36 BT is designed to record the thermal gradient of the water at various depths. The primary source of contaminants in each sonobuoy is the seawater battery; these batteries have a maximum operational life of 8 hours, after which the chemical constituents in the battery are consumed. As described in Section 3.2, the immediate water and sediment quality may be affected by chemical leaching from expended sonobuoys, but ocean and tidal current will quickly disperse chemicals to nontoxic levels.

Given the size of the TMAA and the low number of sonobuoys used, it would be very unlikely that fish would be affected by use of sonobuoys. Sonobuoy emissions are not anticipated to accumulate or result in additive effects on water or sediment quality as would occur within an enclosed body of water since the constituents of sonobuoys would be widely dispersed in space and time throughout training areas. In addition, dispersion of released metals and other chemical constituents due to currents near the ocean floor would help minimize any long-term degradation of water and sediment quality. Therefore, sonobuoy-related materials under the No Action Alternative may have a short-term and localized effect, but would not result in adverse effects to fish populations or EFH as defined under the MSFCMA. In accordance with EO 11214, harm to fish populations or habitat from sonobuoy related materials in nonterritorial seas would be minimal under the No Action Alternative.

Summary of Impacts from Expended Materials

Nonexplosive training round, target, sonobuoy, chaff, and marine marker use under the No Action Alternative may affect fish, but the effects would be minimal because these elements of the action are not expected to have measurable or detectable impacts to fish. Expended materials under the No Action Alternative would not result in adverse affects to fish populations or EFH as defined under the MSFCMA. In accordance with EO 11214, harm to fish populations or habitat from expended materials in nonterritorial seas would be minimal under the No Action Alternative.

Threatened and Endangered Species, and Critical Habitat

As discussed in Section 3.6.1.3, species of ESA-designated salmonids with known or potential occurrence in the TMAA include: Chinook, coho, chum, and sockeye salmon; and steelhead. No critical habitat (e.g., riparian, estuarine, nearshore marine, or offshore marine) occurs within the TMAA; however, impacts may occur to migratory juvenile or adult individuals, as discussed above for each activity. Based on analysis methods presented in Section 3.6.2.2, physical injury to salmonids could occur within the distances of an explosion shown in Tables 3.6-5 and 3.6-6. Fish injury and mortality from explosions are reduced by Navy protective measures, as discussed in Chapter 5. The Navy finds the activities associated with the No Action Alternative may affect the threatened salmonid species in the TMAA and the Navy is currently conducting ESA Section 7 consultations with NMFS to address effects to listed fish species for the Preferred Alternative (Alternative 2); however, no destruction or adverse modification of designated critical habitat would result from implementation of the No Action Alternative.

Essential Fish Habitat

This section discusses the potential impacts of the No Action Alternative to EFH and managed species. Species within all FMPs may utilize both nearshore and offshore areas during their lives, as eggs and larvae for most species are planktonic and can occur in nearshore and offshore waters, while adults may be present in nearshore and/or offshore waters. Therefore, all project activities under the No Action Alternative can potentially affect a lifestage of a managed species.

The proposed activities in the TMAA have the potential to result in the following impacts:

- Physical disruption of habitat;
- Physical destruction or adverse modification of benthic habitats;
- Alteration of water or sediment quality from expended material or discharge; and
- Cumulative impacts.

Effects to EFH could potentially result from vessel movements, aircraft overflights, explosive ordnance use, sonar activities, nonexplosive ordnance use, weapons firing disturbance, expended materials, and target related materials, all of which have been analyzed in the previous sections, and with a more focused analysis in a separate EFH Assessment. The analyses indicate that impacts to the water column habitat and fish would be short-term and localized, that adverse disturbance to benthic habitats would be unlikely due to the water depth where training activities occur and the avoidance of HAPCs (see Section 3.5, Marine Plants and Invertebrates). Therefore, the No Action Alternative would not result in adverse affects to EFH as defined under the MSFCMA.

3.6.2.4 Alternative 1

Under Alternative 1, the general level of some activities in the TMAA would increase relative to those under the No Action Alternative. In addition, training activities associated with force structure changes would be implemented for the EA-18G Growler, SSGN, P-8 MMA, DDG 1000, and UASs. Force structure changes associated with new weapons systems would include new sonobuoys. Force structure changes associated with new training instrumentation include the PUTR.

Vessel Movements

As described for the No Action Alternative, the number of Navy vessels operating during training activities varies, but generally includes up to seven surface ships and one submarine (collectively referred to as vessels). Under Alternative 1, steaming hours would increase from current conditions, although the increase in steaming hours would not measurably increase potential effects to fish. Disturbance impacts to fish from vessel movements under Alternative 1 would be the same as those described for the No Action Alternative.

Vessel movements under Alternative 1 would not result in adverse effects to fish populations or EFH as defined under the MSFCMA. In accordance with EO 11214 harm to fish populations or habitat from vessel movements in nonterritorial seas would be minimal under Alternative 1.

Aircraft Overflights

As described for the No Action Alternative, aircraft overflight responses would not compromise the general health or condition of individual fish or fish populations, and under Alternative 1, overflights would increase from current conditions. The increase in potential exposure to visual and sound disturbance would not measurably increase effects to fish. Thus, the impacts of overflights under Alternative 1 would be the same as those for the No Action Alternative.

Aircraft overflights under Alternative 1 would not result in adverse effects to fish populations or EFH as defined under MSFCMA. In accordance with EO 11214, harm to fish populations or habitat from aircraft overflights in nonterritorial seas would be minimal under Alternative 1.

Explosive Ordnance

Explosive ordnance use would increase under Alternative 1 compared to the No Action Alternative (Table 3.6-8). In addition, Alternative 1 would include the use of the Improved Extended Echo Ranging (IEER) sonobuoys (IEER will be replaced by the Multi-Static Active Coherent [MAC] sonobuoy). Unlike other sonobuoys, IEER sonobuoys contain two Signal, Underwater Sound (SUS) explosive payloads (Class A) weighing 4.2 lb (1.9 kg) each. Explosive source sonobuoys could affect water quality by the release of explosive by-products, and could affect bottom habitats releasing chemicals (primarily from batteries) into the sediment. The sonobuoy explosive package consists primarily of HLX (i.e., explosive cord) and small amounts of plastic-bonded molding powder. Explosions create gaseous by-products, many of which travel to the surface and escape into the atmosphere. A small amount of the gas, however, dissolves into the water column. Although several by-products are produced, the products with greatest potential to result in toxicity are hydrogen fluoride compounds. However, only a minute amount of these substances are expected to be introduced, and they would be rapidly diluted by water movement. It is therefore considered unlikely that the explosive reactions associated with sonobuoys will result in localized impacts.

As described for the No Action Alternative, impacts to fish from explosions would be possible, but these elements of the action are not expected to have measurable or detectable impacts to fish given the vast area encompassing the TMAA (42,146 nm^2 [144,557 km^2]); impacts are further reduced using conservative estimates assuming that activities occur across 20 percent of the TMAA (Table 3.6-8). Habitat disturbance and fish injury and mortality from explosions are reduced by Navy mitigation measures, as discussed in Chapter 5. While serious injury and/or mortality to individual fish would be expected if they were present in the immediate vicinity of explosive ordnance use, explosions under Alternative 1 would not result in impacts to fish populations based on the low number of fish that would be affected. Disturbance to water column and benthic habitats from explosions would be short-term and localized. The effects of other expended materials in sonobuoys (e.g., batteries) are discussed in Section 3.2. In accordance with EO 11214, harm to fish populations or habitat from explosive ordnance use in nonterritorial seas would be minimal under Alternative 1.

Impacts to fish under the No Action Alternative from explosions would be possible, but because these elements of the action are not expected to have measurable or detectable impacts to fish given the vast area encompassing the TMAA (42,146 nm^2 [144,557 km^2]); impacts are further reduced using conservative estimates assuming that activities occur across 20 percent of the TMAA (Table 3.6-8).

Sonar

Effects to fish populations and EFH from sonar use could potentially result from acoustic impacts if that sonar use was within their auditory or sensory detection capabilities (Table 3.6-10). Anti-Submarine Warfare (ASW) exercises include training sonar operators to detect, classify, and track underwater objects and targets. There are two basic types of sonar: passive and active. Passive sonars only listen to incoming sounds and, since they do not emit sound energy in the water, lack the potential to acoustically affect the environment. Active sonars emit acoustic energy to obtain information about a distant object from the reflected sound energy. Active sonars are the most effective detection systems against modern, ultra-quiet submarines and sea mines in shallow water.

Modern sonar technology has developed a multitude of sonar sensor and processing systems. In concept, the simplest active sonars emit acoustic pulses (“pings”) and time the arrival of the reflected echoes from the target object to determine range. More sophisticated active sonars emit a ping and then scan the received beam to provide directional as well as range information. Only about half of the Navy’s ships are equipped with active sonar and their use is generally limited to training and maintenance activities; 90 percent of sonar activity by the Navy is passive (DoN 2007).

Active sonars operate at different frequencies, depending on their purpose. High-frequency sonar (>10 kHz) is mainly used for establishing water depth, detecting mines, and guiding torpedoes. At higher frequencies, sound energy is greatly attenuated by scattering and absorption as it travels through the water. This results in shorter ranges, typically less than 5 nm (9.2 km). Mid-frequency sonar is the primary tool for identifying and tracking submarines. Mid-frequency sonar (1 kHz - 10 kHz) suffers moderate attenuation and has typical ranges of 1-10 nm (1.8-18.5 km). Low-frequency sonar (<1 kHz) has the least attenuation, achieving ranges over 100 nm (185 km). Low-frequency sonars are primarily used for long-range search and surveillance of submarines. SURTASS LFA is the U.S. Navy’s low-frequency sonar system (DoN 2001b); it employs a vertical array of 18 projectors using the 100-500 Hz frequency range but is not proposed for use in the TMAA.

Sonars used in ASW are predominantly in the mid-frequency range (DoN 2007). ASW sonar systems may be deployed from surface ships, submarines, and rotary and fixed wing aircraft. The surface ships are typically equipped with hull-mounted sonar but may tow sonar arrays as well. Helicopters are equipped with dipping sonar (lowered into the water). Helicopters and fixed wing aircraft may also deploy both active and passive sonobuoys and towed sonar arrays to search for and track submarines.

Submarines also use sonars to detect and locate other subs and surface ships. A submarine’s mission revolves around stealth, and therefore submarines use their active sonar very infrequently since the pinging of active sonar gives away their location. Submarines are also equipped with several types of auxiliary sonar systems for mine avoidance, for top and bottom soundings to determine the submarine’s position in the water column, and for acoustic communications. ASW training targets simulating submarines may also emit sonic signals through acoustic projectors.

Table 3.6-10: Active Systems and Platforms Proposed for Use in the TMAA

System	Hours Modeled (Annual)		Associated Platform/Use
	Alt 1	Alt 2	
AN/SQS-53	289	578	DDG and CG hull-mounted sonar
AN/SQS-56	26	52	FFG hull-mounted sonar
AN/BQQ-10	24	48	Submarine hull-mounted sonar
AN/AQS-13 or AN/AQS-22	96	192	Helicopter dipping sonar
BQS-15	12	24	SSN navigation
PUTR Transponders	40	80	Portable Undersea Tracking Range
MK-84 Range Tracking Pingers	40	80	Ships, submarines, ASW targets
DICASS sonobuoy (AN/SSQ-62)	133	266	MPA deployed sonobuoys
IEER Sonobuoy (AN/SSQ-110A)	20	40	MPA deployed sonobuoys
MAC Sonobuoy (AN/SSQ-125)	20	40	MPA deployed sonobuoys
SUS, MK-84	12	24	Surface Ships and Aircraft
EMATT	6	12	Surface Ships and Aircraft

CG – Guided Missile Cruiser; DDG – Guided Missile Destroyer; FFG – Fast Frigate; DICASS – Directional Command-Activated Sonobuoy System; HF – High-Frequency; MF – Mid-Frequency.

Torpedoes use high-frequency, low-power, active sonar. Their guidance systems can be autonomous or electronically controlled from the launching platform through an attached wire. The autonomous guidance systems are acoustically based. They operate either passively, exploiting the emitted sound energy by the target, or actively, ensonifying the target and using the received echoes for tracking and targeting.

Military sonars for establishing depth and most commercial depth sounders and fish finders operate at high frequencies, typically between 24 and 200 kHz. Although low-frequency sonar is not proposed for use in the TMAA, the following text summarizes the types and potential impacts associated with the three main types of sonar.

Low-Frequency Sonar

Low-frequency sound travels efficiently in the deep ocean and is used by whales for long-distance communication (Richardson et al. 1995, NRC 2003, 2005). Concern about the potential for low-frequency sonar (<1 kHz) to interfere with cetacean behavior and communication has prompted extensive debate and research (DoN 2001b, 2007, NRC 2000, 2003).

Some studies have shown that low-frequency sound will alter the behavior of fish. For example, research on low-frequency devices used to deter fish away from turbine inlets of hydroelectric power plants showed stronger avoidance responses from sounds in the infrasound range (5-10 Hz) than from 50 and 150 Hz sounds (Knudsen et al. 1992, 1994). In test pools, wild salmon exhibit an apparent avoidance response by swimming to a deeper section of the pool when exposed to low-frequency sound (Knudsen et al. 1997).

Turnpenny et al. (1994) reviewed the risks to marine life, including fish, of high intensity, low-frequency sonar. Their review focused on the effects of pure tones (sine waves) at frequencies between 50 Hz and 1 kHz. Johnson (2001) evaluated the potential for environmental impacts of employing the SURTASS LFA sonar system. While concentrating on the potential effects on whales, the analysis did consider the potential effects on fish, including bony fish and sharks. It appears that the swimbladders of most fish are too small to resonate at low frequencies and that only large pelagic species such as tunas have swimbladders big enough to resonate in the low-frequency range. However, investigations by Sand and Hawkins (1973) and Sand and Karlsen (1986) revealed resonance frequencies of cod swim bladders from 2 kHz down to 100 Hz.

Popper et al. (2005, 2007) investigated the impact of Navy SURTASS LFA sonar on hearing and on nonauditory tissues of several fish species. In this study, three species of fish in Plexiglass cages suspended in a freshwater lake were exposed to high-intensity LFA sonar pulses for periods of time considerably longer than likely LFA exposure. Kane et al. (2010) also conducted similar experiments using LFA, and similarly, results showed no mortality and no damage to body tissues either at the gross or histological level. Some individuals exhibited temporary hearing loss but recovered within several days of exposure. They noted that it could be possible that wild fishes (not caged) exposed to high intensity sounds might show behavioral responses that may affect feeding, reproduction, exposure avoidance or other important behaviors; however, the studies suggest that SURTASS LFA sonar does not kill or damage fish even in a worst case scenario.

Mid-Frequency Sonar

ASW training activities use sound sources mainly in the mid-frequency (1 kHz - 10 kHz) range and at or above the 3.5 kHz center frequency of the SQS-53 hull mounted sonar. The best available science indicates that with few exceptions, fish cannot hear sounds above about 3 kHz, and the majority of species are only able to detect sounds to 1 kHz or even below (Popper 2003, Hastings and Popper 2005). Thus, it is expected that most fish species would not be able to hear the ASW mid-frequency sonar proposed for use in the TMAA.

Some investigations have been conducted on the effect on fish of acoustic devices designed to deter marine mammals from gillnets (Gearin et al. 2000, Culik et al. 2001). While the devices used in these experiments had output that included a portion of the mid-frequency range, they are not otherwise similar to the sonar devices that would be used in ASW exercises. Gearin et al. (2000) concluded adult sockeye salmon were not disturbed by the sound from these devices. In field experiments to determine the reactions of herring (*Clupea harengus*) and harbor porpoise to acoustic alarm deterrent devices, Culik et al., (2001) found herring were not affected by the devices.

Jørgensen et al. (2005) examined the effects of 1 kHz to 6.5 kHz sounds on survival, development, and behavior of fish larvae and juvenile Atlantic herring (*Clupea harengus*), Atlantic cod (*Gadus morhua*), saithe (*Pollachius virens*), and spotted wolfish (*Anarhichas minor*). Swimbladder resonance experiments were also attempted on the herring, cod, and saithe. The investigators variously characterized the sound sources used in these exposure experiments as “low frequency sonar”, “Low Frequency Active Sonars (MFAS)” and as having “simulating real sonar” and “sonar signals” but all in reference to sonar systems on Royal Norwegian Navy frigates and helicopters. The sounds tested were unlike any produced from U.S. Navy sonar[3] proposed for use in the TMAA but do provide data points for understanding affects from sound exposures longer in duration and closer to the center frequency of hearing for these species.

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[3] For example U.S. Navy hull mounted mid-frequency anti-submarine systems do not include the 1.5 kHz range; the SQS-53 has a center frequency at 3.5 kHz; The continuous wave sounds were one second in duration repeated every five seconds (a least six times more frequent) for up to 100 exposures (too many to be representative; an approximate seven minute exposure); The frequency modulated signals tested were a sweep from 1 kHz to 3 kHz, which is much too broad a frequency sweep.

The 82 experimental exposures by Jørgensen et al. (2005) did not cause any significant direct mortality among the exposed fish except in two experiments[4] where significant mortality (approximately 20 to 30 percent) was observed for some larval and juvenile herring in the group. This was in contrast to the other 40 experiments on larval and juvenile herring having no significant mortality.

Some incidents of behavioral reactions were observed in the herring "during or after" sound at 1.5 kHz or to frequency sweeps (starting at 1 kHz and ending at 3 kHz) for exposures up to 100 seconds in duration. Sounds of this frequency and duration are not like mid-frequency sonar proposed for use in the TMAA. Histological studies found no physiological obvious affects from the sound exposure.

Kvadsheim and Sevaldsen (2005) undertook further analysis of Jørgensen et al. (2005) to determine if use of the same signals were extrapolated to the wild, would there be a significant impact on larvae and juvenile fish over a spawning ground. They conjectured that "normal sonar" operations would affect a smaller percentage than is subject to natural daily mortality. Based on the two incidents of mortality in 40 exposures seen in Jørgensen et al. (2005), Kvadsheim and Sevaldsen (2005) did suggest use of continuous-wave transmissions within the frequency band corresponding to swim bladder resonance of small herring could increase the predicted mortality by an order of magnitude. To reiterate, the sound frequency and duration upon which this prediction was made is not representative of the type of U.S. Navy sonar proposed for use by this EIS/OEIS.

Doksæter et al. (2009) more recently investigated exposure of herring to mid-frequency sonar and concluded that, "the operation of sonar systems at the tested frequencies and source levels above 1 kHz and 209 dB rms re 1 Pa at 1 m will not have any large scale detrimental effects on overwintering herring populations or on the commercial herring fishery." The investigators concluded that, "Military sonars of such frequencies and source levels may thus be operated in areas of overwintering herring without substantially affecting herring behavior or herring fishery" (Doksæter et al. 2009).

Experiments on fish classified as hearing specialists (but not those classified as hearing generalists) have shown that exposure to loud sound can result in temporary hearing loss, but it is not evident that this may lead to long-term behavioral disruptions in fish that are biologically significant (Amoser and Ladich 2003, Smith et al. 2004 a,b). There is no information available that suggests that exposure to nonimpulsive acoustic sources results in fish mortality.

In summary, proposed ASW training activities use mid-frequency sound sources at or above the 3.5 kHz center frequency of the SQS-53 hull mounted sonar and with few exceptions, fish cannot hear sounds above about 3 kHz (Popper 2003, Hastings and Popper 2005). Thus, it is expected that most fish species would not be able to hear the mid-frequency sonar proposed for use in the TMAA. If responses to mid-frequency sonar use do occur, behavioral responses would be brief, reversible, and not biologically significant. Sustained auditory damage is not expected (Kane et al. 2010). Sensitive life stages (juvenile fish, larvae and eggs) very close to the sonar source may experience injury or mortality, but below the level of loss of larval and juvenile fish from natural causes. The use of Navy mid-frequency sonar would not compromise the productivity of fish or adversely affect their habitat.

High-Frequency Sonar

Although most fish cannot hear high frequencies sound, some shad and herring species can detect sounds over 20 kHz. (Mann et al. 2001, Higgs et al. 2004). Ross et al. (1996) reviewed the use of high-frequency

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[4] Experiment 21 - One second exposures every five seconds at 1.5 kHz and 189 dB (20 times) for 100 seconds and Experiment 40 - one second exposures every five seconds at 3.4 kHz and 179 dB (20 times) for 100 seconds.

sound to deter alewives from entering power station inlets and suggested that impingement of alewives was reduced by 81–84%. The alewife, a member of the shad family (Alosinae) which can hear sounds at high frequencies (Mann et al. 2001), uses high-frequency hearing to detect and avoid predation by cetaceans. Wilson and Dill (2002) demonstrated that exposure to broadband sounds with high frequencies cause behavioral modification in Pacific herring.

Since high-frequency sound attenuates quickly in water, high levels of sound from sonars in this range would be restricted to within a few meters of the source. Even for fish able to hear sound at high frequencies, only short-term exposure would occur, thus high-frequency military sonars are not expected to have significant effects on resident fish populations.

Because a torpedo emits sonar pulses intermittently and is traveling through the water at a high speed, individual fish would be exposed to sonar from a torpedo for a brief period. At most, an individual animal would hear one or two pings from a torpedo and would be unlikely to hear pings from multiple torpedoes over an exercise period. Most fish hear best in the low- to mid-frequency range and, therefore, are unlikely to be disturbed by torpedo pings.

The effects of high-frequency sonar on fish behavior for species that can hear high-frequency sonar would be transitory and of little biological consequence. Most species of fish would not hear these sounds and would therefore experience no disturbance.

Conclusion – Sonar Use

While the impact of anthropogenic sound on marine mammals has been extensively studied, the effects of sound on fish are largely unknown (Popper 2003, Hastings and Popper 2005, Popper 2008, Popper and Hastings 2009). There is a dearth of empirical information on the effects of exposure to sound, let alone sonar, for the vast majority of fish. The few studies on sonar effects have focused on behavior of individuals of a few species and it is unlikely their responses are representative of the wide diversity of other marine fish species (Popper and Hastings 2009). The literature on vulnerability to injury from exposure to loud sounds is similarly limited, relevant to particular species, and, because of the great diversity of fish, not easily extrapolated. More well-controlled studies are needed on the hearing thresholds for fish species and on temporary and permanent hearing loss associated with exposure to sounds. The effects of sound may not only be species specific, but also depend on the mass of the fish (especially where any injuries are being considered) and life history phase (eggs and larvae may be more or less vulnerable to exposure than adult fish). The use of sounds during spawning by some fish, and their potential vulnerability to masking by anthropogenic sound sources, also requires further investigation. No studies have established effects of cumulative exposure of fish to any type of sound or have determined whether subtle and long-term effects on behavior or physiology could have an impact upon survival of fish populations. The use of sounds during spawning by some fish and their potential vulnerability to masking by anthropogenic sound sources requires closer investigation.

With these caveats and qualifications in mind, the limited information currently available suggests that populations of fish are unlikely to be affected by the projected rates and areas of use of military sonar. Most fish species are not capable of hearing mid-frequency and high frequency sonar. Short-term behavioral responses such as startle and avoidance may occur, but are not likely to adversely affect indigenous fish communities. Auditory damage from sonar signals is not expected and there is no indication that nonimpulsive acoustic sources would result in mortality to fish populations. Thus, sonar use in TMAA training is not anticipated to result in adverse affects to fish populations or EFH as defined under the MSFCMA. In accordance with EO 11214, harm to fish populations or habitat from sonar use in nonterritorial seas would be minimal under Alternative 1.

Weapons Firing Disturbance

Under Alternative 1, weapons firing activities would increase by 40 percent (Table 3.6-8), but because fish apparently only react to impulsive sounds greater than 160 dB, only those in the immediate vicinity (0.004 nm^2 [0.015 km^2] area) would be affected and effects would be limited to short-term, transitory alarm or startle responses. Since activities are infrequent and widely dispersed throughout the TMAA, the impacts to fish would be the same as those described for the No Action Alternative.

Under Alternative 1, weapons firing may affect fish, but this effect would be minimal. Weapons firing under Alternative 1 would not result in adverse effects to fish populations or EFH as defined under the MSFCMA. Furthermore, harm to fish from weapons firing would not be likely in nonterritorial seas in accordance with EO 12114.

Expended Materials

Under Alternative 1, the total number of expended ordnance in the TMAA would be 20,223 items per year, an increase of 26 percent. Based on an open ocean area of 42,146 nm^2 (144,557 km^2) and conservatively assuming that activities occur across 20 percent of the TMAA, 2.4 items per nm^2 (0.07 per km^2) per year would be deposited in the ocean (see Table 3.6-9). More than 93 percent of these items would be from gunshells and small caliber rounds.

The increase in potential exposure would not measurably increase effects to fish. Given the large area of the TMAA and low concentration of expended materials, with no potential for long-term degradation of water and sediment quality (See Section 3.2, Expended Materials, and 3.3, Water Resources), the impacts to fish would be the same as those described for the No Action Alternative. Similarly, ingestion of expended materials is possible, but has a low potential for occurrence, as described for the No Action Alternative. Habitat disturbance and fish injury and mortality from expended materials use are reduced by Navy mitigation measures, as discussed in Chapter 5. While serious injury and/or mortality to individual fish would be expected if they were present in the immediate vicinity of expended materials contacting the ocean surface, implementation of Alternative 1 would not result in impacts to fish populations based on the low number of fish that would be affected. Disturbances to water column and benthic habitats from expended materials would be short-term and localized.

Expended materials under Alternative 1 would not result in adverse effects to fish populations or EFH as defined under the MSFCMA. In accordance with EO 11214, harm to fish populations or habitat from expended materials in nonterritorial seas would be minimal under Alternative 1.

Portable Undersea Tracking Range

The PUTR is a self-contained, portable, undersea tracking capability that employs modern technologies to support coordinated undersea warfare training for Forward Deployed Naval Forces (FDNF). PUTR will be available in two variants to support both shallow and deep water remote activities in keeping with Navy requirements to exercise and evaluate weapons systems and crews in the environments that replicate the potential combat area. The system will be capable of tracking submarines, surface ships, weapons, targets, and Unmanned Underwater Vehicles (UUVs) and distribute the data to a data processing and display system, either aboard ship, or at a shore site.

No area supporting a PUTR system has been identified; however, potential impacts to EFH can be assessed based on several assumptions. Assuming that transponders are deployed on soft-bottom habitats, impacts would be similar to those discussed for expended materials. There would be direct impact to soft bottom habitat where the clump weight contacted the bottom, which may result in localized mortality to epifauna and infauna within the footprint, although it is anticipated that recolonization would occur within a relatively short period of time. Upon completion of the exercise, the transponders are recovered, which eliminates any potential impacts associated with hazardous materials such as batteries and electronic components. The clump weight is not recovered, and since it is composed of inert material, it is not a potential source of contaminants, and could provide a substrate for benthic fauna. There may also be indirect effects associated with increased turbidity due to resuspension of sediments from the clump weight contacting the bottom. The turbidity plume is expected to be localized and temporary, as sediment would eventually settle to the ocean floor or be dispersed by ocean currents. Therefore, localized and temporary impacts to benthic fauna and water quality may occur from the PUTR, but no long-term impacts are anticipated. Impacts from the PUTR under the Alternative 1 would not result in adverse effects to fish populations or EFH as defined under MSFCMA. In accordance with EO 11214, harm to fish populations or habitat from explosive ordnance use in nonterritorial seas would be minimal under the No Action Alternative.

Threatened and Endangered Species and Critical Habitat

As discussed in Section 3.6.1.3, species of ESA-designated salmonids with known or potential occurrence in the TMAA include Chinook, coho, chum, and sockeye salmon; and steelhead. No critical habitat (e.g., riparian, estuarine, nearshore marine, or offshore marine) occurs within the TMAA. However, impacts may occur to migratory juvenile or adult individuals, as discussed for No Action Alternative. Based on analysis methods presented in Section 3.6.2, physical injury to salmonids could occur within the distances of an explosion shown in Tables 3.6-6 and 3.6-7. Fish injury and mortality from explosions are reduced by Navy protective measures, as discussed in Chapter 5.

Pursuant to the ESA, Section 7, the Navy finds the activities associated with Alternative 1 may affect the threatened salmonid species in the TMAA; the Navy is currently conducting Section 7 consultations with NMFS to address effects to listed fish species for the Preferred Alternative (Alternative 2). No destruction or adverse modification of designated critical habitat would result from implementation of Alternative 1.

Essential Fish Habitat

Under Alternative 1, the level of activities in the TMAA would increase relative to the baseline No Action Alternative. However, these increases would not measurably increase potential effects to EFH. The EFH assessment concludes that vessel movements, aircraft overflights, explosive ordnance use, sonar activities, weapons firing disturbance, expended materials, and target related materials under Alternative 1 would not result in adverse affects to EFH as defined under the MSFCMA.

3.6.2.5 Alternative 2

Implementation of Alternative 2 would include all elements of Alternative 1 (accommodating training activities currently conducted, increasing specific training activities to include the use of active sonar, and accommodating force structure changes). In addition, under Alternative 2 the following activities would occur:

- Conduct one additional separate summertime CSG exercise lasting up to 21 days within the ATA.
- Conduct a SINKEX in each summertime exercise (a maximum of two) in the TMAA.

Vessel Movements

As described for the other alternatives, the number of Navy vessels operating during training exercises varies and would average eight vessels per activity. Under Alternative 2, steaming hours would increase from current conditions, although the increase in steaming hours would not measurably increase potential effects to fish. Disturbance impacts to fish from vessel movements under Alternative 2 would be the same as those described for the No Action Alternative.

Vessel movements under Alternative 2 would not result in adverse effects to fish populations or EFH as defined under the MSFCMA. Furthermore, harm to fish populations or habitat from vessel movements in nonterritorial seas would be minimal in accordance with EO 11214.

Aircraft Overflights

As described for the No Action Alternative, aircraft overflight responses would not compromise the general health or condition of individual fish or fish populations, and under Alternative 2, overflights would increase from current conditions. The increase in potential exposure to visual and sound disturbance would not measurably increase effects to fish. Thus, the impacts of overflights under Alternative 2 would be the same as those for the No Action Alternative.

Aircraft overflights under Alternative 2 would not result in adverse effects to fish populations or EFH as defined under MSFCMA. Furthermore, harm to fish populations or habitat from aircraft overflights in nonterritorial seas would be minimal in accordance with EO 11214.

Explosive Ordnance

Explosive ordnance use would increase under Alternative 2 compared to the No Action Alternative (Table 3.6-8). And similar to Alternative 1, Alternative 2 would include the use of the IEER sonobuoy. As described for the No Action Alternative, impacts to fish from explosions would be possible, but these elements of the action are not expected to have measurable or detectable impacts to fish given the vast area encompassing the TMAA (42,146 nm^2 [144,557 km^2]); impacts are further reduced using conservative estimates assuming that activities occur across 20 percent of the TMAA (Table 3.6-8). Habitat disturbance and fish injury and mortality from explosions are reduced by Navy mitigation measures, as discussed in Chapter 5. While serious injury and/or mortality to individual fish would be expected if they were present in the immediate vicinity of explosive ordnance use, explosions under Alternative 2 would not result in impacts to fish populations based on the low number of fish that would be affected. Disturbances to water column and benthic habitats from explosions would be short-term and localized. The effects of other expended materials in sonobuoys are discussed in Section 3.2.

Sonar

Under Alternative 2, sonar would have the potential to affect fish in the TMAA. Most fish species would not be able to detect mid-frequency and high frequency sonar. Short-term behavioral responses such as startle and avoidance may occur, but are not likely to adversely affect indigenous fish communities. Auditory damage from sonar signals is not expected and there is no indication that nonimpulsive acoustic sources result in fish mortality. Sonar use under Alternative 2 would not result in adverse effects to fish populations or EFH as defined under the MSFCMA. Furthermore, harm to fish populations or habitat from sonar use in nonterritorial seas would be minimal in accordance with EO 11214.

Weapons Firing Disturbance

Under Alternative 2, weapons firing activities would increase by 180 percent (Table 3.6-8), but because fish apparently only react to impulsive sounds greater than 160 dB, only those in the immediate vicinity (0.015 km^2 area) would be affected and effects would be limited to short-term, transitory alarm or startle responses. Since activities are infrequent and widely dispersed throughout the TMAA, the impacts to fish would be the same as those described for the No Action Alternative.

Under the Alternative 2, weapons firing may affect fish, but this affect would be minimal. Weapons firing under Alternative 2 would not result in adverse effects to fish populations or EFH as defined under the MSFCMA. Furthermore, harm to fish from weapons firing would not be likely in nonterritorial seas in accordance with EO 12114.

Expended Materials

Under Alternative 2, expended materials in the TMAA would increase approximately 160 percent over the No Action Alternative (see Table 3.6-9). Based on an open ocean area of 42,146 nm^2 (144,557 km^2) and conservatively assuming that activities occur across 20 percent of the TMAA, 4.9 items per nm^2 (1.4 per km^2) per year would be deposited in the ocean. More than 91 percent of these items would be from gunshells and small caliber rounds. Despite the increase in expended materials, given the large area of the TMAA and low concentration of expended materials, with no potential for long-term degradation of water and sediment quality (See Section 3.2, Expended Materials, and 3.3, Water Resources), the impacts to fish would be the same as those described for the No Action Alternative.

Under Alternative 2, ingestion of expended materials is possible, but has a low potential for occurrence, as described for the No Action Alternative. Expended materials under Alternative 2 would not result in adverse effects to fish populations or EFH as defined under the MSFCMA. Furthermore, harm to fish populations or habitat from expended materials in nonterritorial seas would be minimal in accordance with EO 11214.

Portable Undersea Tracking Range

Under Alternative 2, impacts from the PUTR would be similar to those described for Alternative 1, with localized and temporary impacts to benthic fauna, water quality, and EFH, but no long-term adverse impacts are anticipated.

SINKEX

Under Alternative 2, a SINKEX is typically conducted by aircraft, surface ships, and submarines in order to take advantage of a full size ship target and an opportunity to fire live weapons. The target is typically a decommissioned combatant or merchant ship that has been made environmentally safe for sinking according to standards set by the U.S. Environmental Protection Agency (USEPA). It is placed in a specific location that is greater than 50 nm (93 km) out to sea and in water depths greater than 6,000 ft (1,830 m) (40 C.F.R. § 229.2) so that when it sinks it will serve another purpose, such as a reef, or be in deep water where it will not be a navigation hazard to other shipping. Ship, aircraft, and submarine crews typically are scheduled to attack the target with coordinated tactics and deliver live ordnance to sink the target.

Aspects of the exercise that have potential effects on fish are vessel movement, aircraft overflights, active sonar, surface firing noise, shock waves from munitions hitting the water, munitions constituents, missile launches, shock waves, underwater detonations, and presence of expended materials (fragments of missiles and bombs). These stressors have been analyzed separately in previous sections, and while serious injury and/or mortality to individual fish would be expected if they were present in the immediate vicinity of several of these stressors (e.g., explosive ordnance), SINKEX under Alternative 2 would not result in impacts to fish populations based on the low number of fish that would be affected and the avoidance of HAPCs. Disturbances to water column and benthic habitats from SINKEX would be short-term and localized (See Section 3.5).

Threatened and Endangered Species and Critical Habitat

As discussed in Section 3.6.1.3, species of ESA-designated salmonids with known or potential occurrence in the TMAA include Chinook, coho, chum, and sockeye salmon; and steelhead. No critical habitat (e.g., riparian, estuarine, nearshore marine, or offshore marine) occurs within the TMAA. However, impacts may occur to migratory juvenile or adult individuals, as discussed for No Action Alternative. Based on analysis methods presented in Section 3.6.2, physical injury to salmonids could occur within the distances of an explosion shown in Tables 3.6-6 and 3.6-7. Fish injury and mortality from explosions are reduced by Navy protective measures, as discussed in Chapter 5.

Pursuant to the ESA, Section 7, the Navy finds the activities associated with Alternative 2 may affect the threatened salmonid species in the TMAA; the Navy is currently conducting Section 7 consultations with NMFS to address effects to listed fish species for the Preferred Alternative (Alternative 2). No destruction or adverse modification of designated critical habitat would result from implementation of Alternative 2.

Essential Fish Habitat

Under Alternative 2, the level of activities in the TMAA would increase relative to the baseline No Action Alternative. However, these increases would not measurably increase potential effects to EFH. The EFH assessment concludes that vessel movements, aircraft overflights, explosive ordnance use, sonar activities, weapons firing disturbance, expended materials, and target-related materials under Alternative 2 would not result in adverse affects to EFH as defined under the MSFCMA.

3.6.3 Mitigation

As summarized in Section 3.6.4, the alternatives proposed in the EIS/OEIS would be expected to affect individual fish and have localized effects on their habitats, but would not affect communities or populations of species or their use of the TMAA. Mitigation measures for at-sea activities involving explosive ordnance, implemented for marine mammals and sea turtles, also offer protections to habitats associated with fish communities. These current protective measures detailed in Chapter 5 (such as utilization of general maritime measures and buffer zones for marine mammals as well as marine vegetative communities) would continue to be implemented, and no further mitigation measures would be needed to protected fish in the TMAA.

3.6.4 Summary of Effects by Alternative

Table 3.6-11 summarizes the effects of the No Action Alternative, Alternative 1, and Alternative 2 on fish and EFH under both NEPA and EO 12114.

Table 3.6-11: Summary of Effects by Alternative

Alternative	NEPA (U.S. Territorial Seas, 0 to 12 nm)	EO 12114 (Non-U.S. Territorial Seas, > 12 nm)
No Action Alternative	• Overflights would not adversely affect fish populations or EFH as defined under the MSFCMA. See page 3.6-30.	• Vessel movement, aircraft overflight, weapons firing disturbance, and expended materials would result in minimal harm to fish or EFH. Given the TMAA size and using conservative estimates, the concentration of expended materials would be 1.9 per nm^2 (0.5 per km^2). More than 97 percent of these items would be from gunshells and small caliber rounds. • Explosive ordnance use may result in injury or mortality to individual fish but would not result in impacts to fish populations. Given the TMAA size and using conservative estimates, the concentration of explosive ordnance would be 0.010 per nm^2 (0.003 per km^2). • Activities would not adversely affect fish populations or EFH as defined under the MSFCMA. • May affect ESA-listed fish species. • No effect to designated critical habitat.

Table 3.6-11: Summary of Effects by Alternative (continued)

Alternative	NEPA (U.S. Territorial Seas, 0 to 12 nm)	EO 12114 (Non-U.S. Territorial Seas, > 12 nm)
Alternative 1	• Overflights would not adversely affect fish populations or EFH as defined under the MSFCMA. See page 3.6-38.	• Vessel movement, aircraft overflight, weapons firing disturbance, and expended materials would result in minimal harm to fish or EFH. Given the TMAA size and using conservative estimates, the concentration of expended materials would be 2.4 per nm^2 (0.7 per km^2). More than 93 percent of these items would be from gunshells and small caliber rounds. • Explosive ordnance use may result in injury or mortality to individual fish but would not result in impacts to fish populations. Given the TMAA size and using conservative estimates, the concentration of explosive ordnance would be 0.020 per nm^2 (0.006 per km^2). • Because only a few species of fish may be able to hear the relatively higher frequencies of mid-frequency sonar, sonar used in Navy exercises would result in minimal harm to fish or fish habitat. • Activities would not adversely affect fish populations or EFH as defined under the MSFCMA.. • May affect ESA-listed species. • No effect to designated critical habitat.

Table 3.6-11: Summary of Effects by Alternative (continued)

Alternative	NEPA (U.S. Territorial Seas, 0 to 12 nm)	EO 12114 (Non-U.S. Territorial Seas, > 12 nm)
Alternative 2 (Preferred Alternative)	• Overflights would not adversely affect fish populations or EFH as defined under the MSFCMA. See page 3.6-45.	• Vessel movement, aircraft overflight, weapons firing disturbance, and expended materials would result in minimal harm to fish or EFH. Given the TMAA size and using conservative estimates, the concentration of expended materials would be 4.9 per nm^2 (1.4 per km^2). More than 91 percent of these items would be from gunshells and small caliber rounds. • Explosive ordnance use may result in injury or mortality to individual fish but would not result in impacts to fish populations. Given the TMAA size and using conservative estimates, the concentration of explosive ordnance would be 0.142 per n^{m2} (0.041 per k^{m2}). • Because only a few species of fish may be able to hear the relatively higher frequencies of mid-frequency sonar, sonar used in Navy exercises would result in minimal harm to fish or fish habitat. • Activities would not adversely affect fish populations or EFH as defined under the MSFCMA. No SINKEXs would be conducted in HAPCs. • May affect ESA-listed species. • No effect to designated critical habitat.

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