3.9 Fishes

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3.9 Fishes

3.9.1 Introduction and Methods

This section analyzes the potential impacts of the Proposed Action on fishes found in the Northwest Training and Testing (NWTT) Study Area (Study Area). Section 3.9 (Fishes) provides a synopsis of the United States (U.S.) Department of the Navy's (Navy's) determinations of the impacts of the Proposed Action on fishes. Section 3.9.2 (Affected Environment) introduces the species and taxonomic groups known to occur in the Study Area and discusses the baseline affected environment. The complete analysis of environmental consequences is in Section 3.9.3 (Environmental Consequences).

For this Supplemental Environmental Impact Statement (EIS)/Overseas Environmental Impact Statement (OEIS) (Supplemental), marine and anadromous fishes are evaluated as groups of species characterized by distribution, body type, or behavior relevant to the stressor being evaluated. Activities are evaluated for their potential impact on all fishes in general, by taxonomic groupings, and the 34 fish in the Study Area listed under the Endangered Species Act (ESA).

Major taxonomic groups in the Study Area are described in the 2015 NWTT Final EIS/OEIS and remain valid as written. Fish species listed under the ESA are updated in this document. Marine fish species that are regulated under the Magnuson-Stevens Fishery Conservation and Management Act are discussed in Section 3.9.2.5 (Federally Managed Fisheries). Additional general information on the biology, life history, distribution, and conservation of marine and anadromous fishes can be found on the websites of the following agencies and organizations, as well as many others:

- National Marine Fisheries Service (NMFS), Office of Protected Resources (including ESA-listed species distribution maps)
- Regional Fishery Management Councils
- International Union for Conservation of Nature
- Essential Fish Habitat Text Descriptions

Fishes are not distributed uniformly throughout the Study Area but are closely associated with a variety of habitats. Some species, such as large sharks, tuna, and billfishes, range across thousands of square miles (thousands of square kilometers), while others have small home ranges and restricted distributions (Helfman et al., 2009a). The movements of some open-ocean species may never overlap with coastal species that spend their lives within several hundred feet (a few hundred meters) of the shore. Even within species, the distribution and specific habitats in which individuals occur may be influenced by age, developmental stage, size, sex, reproductive condition, health, and other factors.

3.9.2 Affected Environment

For purposes of this Supplemental, the region of influence for fishes remains the same as that identified in the 2015 NWTT Final EIS/OEIS.

The 2015 NWTT Final EIS/OEIS provided a general overview of fish hearing and vocalizations and general threats. New information since the publication of the 2015 NWTT Final EIS/OEIS is included below to better understand potential stressors and impacts on fishes resulting from training and testing activities.

3.9.2.1 Hearing and Vocalization

A summary of fish hearing and vocalizations is described in the 2015 NWTT Final EIS/OEIS. Due to the availability of new literature, including revised sound exposure criteria, the information provided below will supplement the 2015 NWTT Final EIS/OEIS for fishes.

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

Although a propagating sound wave contains pressure and particle motion components, particle motion is most significant at low frequencies (up to at least 400 Hz) and is most detectible at high sound levels or very close to a sound source. The inner ears of fishes are directly sensitive to acoustic particle motion rather than acoustic pressure (acoustic particle motion and acoustic pressure are discussed in Appendix D, Acoustic and Explosive Concepts). Historically, studies that have investigated hearing in, and effects to, fishes have been carried out with sound pressure metrics. Although particle motion may be the more relevant exposure metric for many fish species, there is little data available that actually measures it due to a lack of standard measurement methodology and experience with particle motion detectors (Hawkins et al., 2015; Martin et al., 2016). In these instances, particle motion can be estimated from pressure measurements (Nedelec et al., 2016a).

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

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

- Fishes without a swim bladder—hearing capabilities are limited to particle motion detection at frequencies well below 2 kilohertz (kHz).
- Fishes with a swim bladder not involved in hearing—species lack notable anatomical specializations, and primarily detect particle motion at frequencies below 2 kHz.
- Fishes with a swim bladder involved in hearing—species can detect frequencies below 2 kHz and possess anatomical specializations to enhance hearing and are capable of sound pressure detection up to a few kHz.

- Fishes with a swim bladder and high-frequency hearing—species can detect frequencies below 2 kHz and possess anatomical specializations and are capable of sound pressure detection at frequencies up to 10 kHz to over 100 kHz.

Both the quantitative literature review conducted by Wiernicki et al. (2020) and x-ray and image processing performed by Schulz-Mirbach et al. (2020), and hearing measurements and dissections of black sea bass by Stanley et al. (2020) continue to support the above hearing group classifications. Additional research is still needed to better understand species-specific frequency detection capabilities and overall sensitivity to sound.

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

Species listed under the ESA within the Study Area include several salmonid and rockfish species, as well as Pacific eulachon and green sturgeon. Species-specific hearing studies for each of the ESA-listed species present in the Study Area are not available. Instead, each ESA-listed species is considered part of a hearing group described above based on data from similar, or surrogate, species, and knowledge of that species physiology. As discussed above, most marine fishes investigated to date lack hearing capabilities greater than 1,000 Hz. This notably includes sturgeon and salmonid species, fishes that have a swim bladder that is not involved in hearing. Although it is assumed that sturgeon and salmon species can detect frequencies up to 1,000 Hz, available hearing data has only tested these species up to about 800 Hz (Hawkins & Johnstone, 1978; Kane et al., 2010; Lovell et al., 2005; Meyer et al., 2010; Tavolga & Wodinsky, 1963). Rockfish also have a swim bladder that is not involved in hearing similar to Salmoniformes (Hastings & Popper, 2005) and therefore likely have similar hearing capabilities. Eulachon do not have a swim bladder (Gauthier & Horne, 2004). Available data suggest species without a swim bladder can detect sounds from 20 to 1,000 Hz, with best sensitivity at lower ranges (Casper et al., 2003; Casper & Mann, 2006; Casper & Mann, 2009; Myrberg, 2001). This data is largely derived from studies conducted using cartilaginous fishes, such as sharks and rays. There are no ESA-listed species that occur in the Study Area that have a swim bladder that is involved in hearing, or that have high frequency hearing (the two most sensitive hearing groups).

Some fishes are known to produce sound. Bony fishes can produce sounds in a number of ways and use them for a number of behavioral functions (Ladich, 2008, 2014). Over 30 families of fishes are known to use vocalizations in aggressive interactions, and over 20 families are known to use vocalizations in mating (Ladich, 2008). Sounds generated by fishes as a means of communication are generally below 500 Hz (Slabbekoorn et al., 2010). The air in the swim bladder is vibrated by the sound producing structures (often muscles that are integral to the swim bladder wall) and radiates sound into the water (Zelick et al., 1999). Sprague and Luczkovich (2004) calculated that silver perch, of the family Sciaenidae, can produce drumming sounds ranging from 128 to 135 decibels referenced to 1 micropascal (dB re 1 µPa). Female midshipman fish apparently detect and locate the “hums” (approximately 90 to 400 Hz) of vocalizing males during the breeding season (McIver et al., 2014; Sisneros & Bass, 2003). Sciaenids produce a variety of sounds, including calls produced by males on breeding grounds (Ramcharitar et al., 2001), and a “drumming” call produced during chorusing that suggests a seasonal pattern to reproductive-related function (McCauley & Cato, 2000). Other sounds produced by chorusing reef fishes include “popping,” “banging,” and “trumpet” sounds; altogether, these choruses produce sound levels 35 decibels (dB) above background levels, at peak frequencies between 250 and 1,200 Hz, and source levels between 144 and 157 dB re 1 µPa (McCauley & Cato, 2000).

Additional research using visual surveys (such as baited underwater video and monitoring by divers) and passive acoustic monitoring continue to reveal new sounds produced by fishes, both in the marine and freshwater environments, and allow for specific behaviors to be paired with those sounds (Radford et al., 2018; Rountree et al., 2018; Rowell et al., 2020; Rowell et al., 2018).

3.9.2.2 General Threats

A summary of the major threats to fish species within the Study Area are described in the 2015 NWTT Final EIS/OEIS. Overfishing and associated factors, such as bycatch, fisheries-induced evolution, and intrinsic vulnerability to overfishing were described. Two species present in the Study Area, coho salmon (*Oncorhynchus kisutch*) stocks in Hood Canal, Washington, and yelloweye rockfish (*Sebastes ruberrimus*), were listed as overfished in a 2016 NMFS Federal Register (FR) notice (National Marine Fisheries Service, 2016). Another species present in the Study Area, Pacific ocean perch (*Sebastes alutus*), was previously considered overfished but is now considered “rebuilt” and not subject to overfishing, according to the 2017 stock assessment (National Marine Fisheries Service, 2020).

Pollution, including the effect of oceanic circulation patterns scattering coastal pollution throughout the open ocean, was described. The effects of organic and inorganic pollutants to marine fishes, including bioaccumulation of pollutants, behavioral and physiological changes, or genetic damage, were described, as well as entanglement in abandoned commercial and recreational fishing gear.

Other human-caused stressors on marine fishes described were the introduction of non-native species, climate change shifting fish distribution from lower to higher latitudes, aquaculture, energy production, vessel movement, and underwater noise.

Climate change related threats impacting marine fish and fisheries in addition to those described in the 2015 NWTT Final EIS/OEIS have been documented. In addition to affecting species ranges, increasing temperature has been shown to alter the sex-ratio in fish species that have temperature-dependent sex determination mechanisms (Ospina-Alvarez & Piferrer, 2008). It appears that diadromous and benthic fish species are most vulnerable to climate change impacts on abundance or productivity (Hare et al., 2016).

Ocean acidification, a climate change related process where increasing atmospheric carbon dioxide concentrations are reducing ocean pH and carbonate ion concentrations, may have serious impacts on fish development and behavior (Munday et al., 2009; Munday et al., 2011; Raven et al., 2005; Williams et al., 2018). Physiological development of fishes can be affected by increases in pH that can increase the size, density, and mass of fish otoliths (e.g., fish ear stones), which would affect sensory functions (Bignami et al., 2013). Ocean acidification may affect fish larvae behavior and could impact fish populations (Munday et al., 2009). A range of behavioral traits critical to survival of newly settled fish larvae are affected by ocean acidification. Settlement-stage larval marine fishes exposed to elevated carbon dioxide were less responsive to threats than controls (Munday et al., 2009). This decrease in sensitivity to risk might be directly related to impaired olfactory ability (Munday et al., 2009). Ocean acidification may cause a shift in phytoplankton community composition and biochemical composition that can impact the transfer of essential compounds to planktivorous organisms (Bermudez et al., 2016) and can cause shifts in community composition up the food chain.

Another effect of climate change is ocean deoxygenation. Netburn and Koslow (2015) found that the depth of the lower boundary of the deep scattering layer (so-called because the sonic pulses of a sonar can reflect off the millions of fish swim bladders) is most strongly correlated with dissolved oxygen concentration.

A study by Deutsch et al. (2015) used climate models to see how the projected temperature and oxygen levels by 2100 due to climate change would affect four ocean species' ability to meet their future energy needs. If current emissions continue, the near-surface ocean is projected to warm by several degrees Celsius by the end of this century. Seawater at that temperature would hold 5–10 percent less oxygen than it does now. The combined effects of warming and oxygen loss this century are projected to reduce the upper ocean's metabolic index by approximately 20 percent globally and by approximately 50 percent in northern high-latitude regions, forcing poleward and vertical contraction of metabolically viable habitats and species ranges. Keller et al. (2015) suggested that within the California Current System, shoaling of the oxygen minimum zone is expected to produce complex changes and onshore movement of the oxygen minimum zone that could lead to habitat compression for species with higher oxygen requirements while allowing expansion of species tolerant of low bottom dissolved oxygen.

With the exception of new information about overfishing and climate change, the extent of the effects of general threats has not changed since they were last described in the 2015 NWTT Final EIS/OEIS. Therefore, the information presented in the 2015 NWTT Final EIS/OEIS remains valid.

3.9.2.3 Taxonomic Group Descriptions and Distribution

Seventeen taxonomic groups of fishes and their distribution in the Study Area (Offshore Area and Inshore Waters and the Western Behm Canal portion of the Study Area) were described in the 2015 NWTT Final EIS/OEIS and summarized in Table 3.9-1. Neither the taxonomic groups nor their distribution within the Study Area has changed since it was last described in the 2015 NWTT Final EIS/OEIS. Therefore, the information presented in the 2015 NWTT Final EIS/OEIS remains valid.

3.9.2.4 Endangered Species Act-Listed Species

There are 33 fish species occurring in the Study Area that are listed as either threatened or endangered under the ESA (Table 3.9-2). NMFS has listed 28 species of salmon and steelhead, two rockfish species, Pacific eulachon, and green sturgeon on the west coast, all of which occur within the Study Area. The U.S. Fish and Wildlife Service (USFWS) has listed bull trout throughout its range, which overlaps with the Study Area. In addition, nine species of concern occur within the Study Area. Species of Concern are identified by NMFS when there is concern regarding species status, but for which insufficient information is available to indicate a need to list the species (69 FR 19975). Candidate species are any species that are undergoing a status review that NMFS has announced through a FR notice (71 FR 61022). Candidate species and Species of Concern do not carry any procedural or substantive protections under the ESA (71 FR 61022). The emphasis on species-specific information in the following profiles will be on the ESA protected species because any threats or potential impacts on those species are subject to consultation with regulatory agencies.

Critical habitat and the associated Primary Constituent Elements (PCEs), if applicable, within the Study Area are identified and described. Potential impacts on critical habitat were assessed by determining the effects of the project on the PCEs of the critical habitat. Critical habitat is defined as (1) specific areas within the geographical area occupied by the species at the time of listing, if those areas 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. PCEs are defined as sites or habitat components that support one or more life stages deemed essential to the conservation of the species. Critical habitat maps were provided only for species in which the critical habitat extended into the Study Area.

The Sikes Act Improvement Act of 1997 (16 United States Code 670a) (Sikes Act) requires each military installation that includes land and water suitable for the conservation and management of natural resources to complete an integrated natural resources management plan (INRMP). NMFS and USFWS shall not designate (exempt) as critical habitat any lands or other geographical areas owned or controlled by the Department of Defense (DoD), or designated for its use, that are subject to an INRMP if the Secretary of the Service determines in writing that such plan provides a benefit to the species for which critical habitat is proposed for designation. Under section 4(b)(2) of the ESA, the Services consider where a national security impact might exist where the benefits of exclusion outweigh the benefits of inclusion.

Since the publication of the 2015 NWTT Final EIS/OEIS, critical habitat has been designated for two threatened species: Puget Sound Steelhead Distinct Population Segment (DPS) and Lower Columbia River coho Salmon Evolutionarily Significant Unit (ESU) (81 FR 9251). Critical habitat designated for Puget Sound steelhead and Lower Columbia River coho salmon is entirely freshwater and marine habitat has not been designated. As a result, there is no critical habitat for these two species in the Study Area. The Puget Sound/Georgia Basin DPS of canary rockfish has been delisted and its designated critical habitat removed (82 FR 7711). Also, bigeye thresher shark, common thresher shark, and smooth hammerhead shark (*Sphyrna zygaena*) have been removed from candidate status after status reviews determined that listing was not warranted (81 FR 18979; 81 FR 41934). Table 3.9-2 contains a summary of the status and presence of all ESA-listed fish species potentially found in the Study Area. The five-year status reviews for all Pacific salmon and steelhead were published in 2016 with no changes in listing status warranted (National Marine Fisheries Service, 2016). In addition, several salmonid hatchery programs have been either added or removed from their respective species' ESUs/DPSs (Jones 2015). With the exception of these recent changes in species status or the inclusion/exclusion of hatchery populations in ESUs/DPSs, the information presented in the 2015 NWTT Final EIS/OEIS remains valid.

Table 3.9-1: Taxonomic Groups of Fishes Within the Northwest Training and Testing Study Area

Taxonomic Groups[1]		Distribution Within Study Area		
Taxonomic Grouping	Description	Offshore Area	Inland Waters	Western Behm Alaska
Hagfish and lamprey (orders Myxiniformes and Petromyzontiformes)	Primitive and jawless with an eel-like body shape that prey on fishes, feed on dead fishes, or are parasitic	Water column, seafloor	Seafloor	Seafloor
Sharks, rays, and chimaeras (class Chondrichthyes)	Cartilaginous (non-bony) fishes, some of which are open ocean predators	Surface, water column, seafloor	Surface, water column, seafloor	Surface, water column, seafloor
Eels and spiny eels (order Anguilliformes))	Undergo a unique larval stage with a small head and elongated body; very different from other fishes	Surface, water column, seafloor	Surface, water column, seafloor	Surface, water column, seafloor
Sturgeons (order Acipenseriformes)	Cartilaginous skeleton, anadromous, and long lived	Water column, seafloor	Water column, seafloor	Water column, seafloor
Herring, eulachon, and salmonids (orders Clupeiformes, Osmeriformes, and Salmoniformes)	Some are anadromous while others are migratory between the ocean, bays, estuaries, and rivers	Surface	Surface, water column	Surface, water column
Lanternfishes (order Myctophiformes)	Largest group of deepwater fishes, most possess adaptations for low-light conditions	Water column	Water column, seafloor	Not Present
Lizardfishes and lancetfishes (order Aulopiformes)	Predatory fish typically found in deep waters	Seafloor	Water column, seafloor	Water column, seafloor
Cods, hakes, and brotulas (orders Gadiformes and Ophidiiformes)	Important commercial fishery resources, associated with bottom habitats	Water column, seafloor	Water column, seafloor	Water column, seafloor
Toadfishes (order Batrachoidiformes)	Temperate and tropical a lie-in-wait predator	Seafloor	Seafloor	Seafloor

Table 3.9-1: Taxonomic Groups of Fishes Within the Northwest Training and Testing Study Area (continued)

Taxonomic Groups[1]		Distribution Within Study Area		
Taxonomic Grouping	**Description**	**Offshore Area**	**Inland Waters**	**Western Behm Alaska**
Pacific saury and Silversides (orders Atheriniformes and Beloniformes)	Small-sized nearshore/coastal fishes, primarily feed on organic debris; also includes the surface-oriented flyingfishes	Surface	Surface, water column	Surface, water column
Opahs and ribbonfishes, (order Lampridiformes)	Primarily open ocean or deepwater fishes	Surface, water column	Surface, water column	Surface, water column
Pipefish and sticklebacks (order Gasterosteiformes)	Small mouth with tubular snout and armor like scales; shows a high level of parental care	None	Surface	Surface
Rockfishes (order Scorpaeniformes)	Larval and juvenile stages pelagic; depending on species, adults bottom oriented or pelagic	Surface, water column, seafloor	Surface, water column, seafloor	Surface, water column, seafloor
Gobies (order Perciformes: family Gobiidae)	Gobies are the largest and most diverse family of marine fishes, mostly found in bottom habitats of coastal areas	None	Bottom Habitat	Surface
Jacks, tunas, and mackerels, (order Perciformes: families Carangidae, Scombridae)	Highly migratory predators found near the surface; they make up a major component of fisheries	Surface	Surface, water column	Surface, water column
Flounders and soles (order Pleuronectiformes)	Occur in bottom habitats throughout the world where they are well camouflaged	Seafloor	Seafloor	Seafloor
Ocean sunfish (*Mola mola*) (order Tetraodontiformes)	Unique body shapes and characteristics to avoid predators	Surface, water column	Surface, water column	Surface, water column

[1] Taxonomic groups are based on the following commonly accepted references: Hart (1973); Helfman et al. (2009b); Moyle & Cech (2004); Nelson et al. (2016).

Table 3.9-2: Status and Presence of Endangered Species Act (ESA)-Listed Fish Species and their Designated Critical Habitat, Candidate Species, and Species of Concern Found in the Northwest Training and Testing Study Area

Species and Regulatory Status				Presence in Study Area		
Common Name (Scientific Name)	**Distinct Population Segment (DPS)[1]/ Evolutionarily Significant Unit (ESU)[2]**	**Federal Status**	**Critical Habitat Designation**	**Offshore Area**	**Inland Waters**	**Western Behm Canal**
Salmonid Species						
Chinook Salmon (*Oncorhynchus tshawytscha*)	Puget Sound ESU	T	Designated (Inland Waters)	✓	✓	✓
	Upper Columbia River Spring-Run ESU	E	Designated (Not in Study Area)	✓		✓
	Lower Columbia River ESU	T	Designated (Not in Study Area)	✓		✓
	Upper Willamette River ESU	T	Designated (Not in Study Area)	✓		✓
	Snake River Spring/Summer-Run ESU	T	Designated (Not in Study Area)	✓		✓
	Snake River Fall-Run ESU	T	Designated (Not in Study Area)	✓		✓
	California Coastal ESU	T	Designated (Not in Study Area)	✓		
	Central Valley, Fall and Late-Fall Run ESU	SOC[3]	Not Designated	✓		
	Central Valley Spring-Run ESU	T	Designated (Not in Study Area)	✓		
	Sacramento River Winter-Run ESU	E	Designated (Not in Study Area)	✓		
Coho Salmon (*Oncorhynchus kisutch*)	Lower Columbia ESU	T	Designated (Not in Study Area)	✓		✓
	Oregon Coast ESU	T	Designated (Not in Study Area)	✓		✓

Table 3.9-2: Status and Presence of Endangered Species Act (ESA)-Listed Fish Species, Candidate Species, and Species of Concern Found in the Northwest Training and Testing Study Area (continued)

Species and Regulatory Status				Presence in Study Area		
Common Name (Scientific Name)	**Distinct Population Segment (DPS)[1]/ Evolutionarily Significant Unit (ESU)[2]**	**Federal Status**	**Critical Habitat Designation**	**Offshore Area**	**Inland Waters**	**Western Behm Canal**
Salmonid Species (continued)						
	Southern Oregon/Northern California Coast ESU	T	Designated (Not in Study Area)	✓		
	Puget Sound/Strait of Georgia ESU	SOC[3]	Not Designated	✓	✓	✓
	Central California Coast ESU	E	Designated (Not in Study Area)	✓		
Chum Salmon (*Oncorhynchus keta*)	Hood Canal Summer-Run ESU	T	Designated (Inland Waters)	✓	✓	
	Columbia River ESU	T	Designated (Not in Study Area)	✓		
Sockeye Salmon (*Oncorhynchus nerka*)	Ozette Lake ESU	T	Designated (Not in Study Area)	✓		
	Snake River ESU	E	Designated (Not in Study Area)	✓		
Steelhead (*Oncorhynchus mykiss*)	Puget Sound DPS	T	Designated (Not in Study Area[4])	✓	✓	
	Upper Columbia River DPS	T	Designated (Not in Study Area)	✓		
	Middle Columbia River DPS	T	Designated (Not in Study Area)	✓		
	Lower Columbia River DPS	T	Designated (Not in Study Area)	✓		
	Upper Willamette River DPS	T	Designated (Not in Study Area)	✓		

Table 3.9-2: Status and Presence of Endangered Species Act (ESA)-Listed Fish Species, Candidate Species, and Species of Concern Found in the Northwest Training and Testing Study Area (continued)

Species and Regulatory Status				Presence in Study Area		
Common Name (Scientific Name)	**Distinct Population Segment (DPS)[1]/ Evolutionarily Significant Unit (ESU)[2]**	**Federal Status**	**Critical Habitat Designation**	**Offshore Area**	**Inland Waters**	**Western Behm Canal**
Salmonid Species (continued)						
	Snake River Basin DPS	T	Designated (Not in Study Area)	✓		
	Northern California Coast DPS	T	Designated (Not in Study Area)	✓		
	Oregon Coast DPS	SOC[3]	Not Designated	✓		
	California Central Valley DPS	T	Designated (Not in Study Area)	✓		
	Central California Coast DPS	T	Designated (Not in Study Area)	✓		
	South-Central California Coast DPS	T	Designated (Not in Study Area)	✓		
	Southern California DPS	E	Designated (Not in Study Area)	✓		
Bull Trout (*Salvelinus confluentus*)	Coastal-Puget Sound DPS	T	Designated (Inland Waters)	✓	✓	
Rockfish Species						
Bocaccio Rockfish (*Sebastes paucispinis*)	Puget Sound/Georgia Basin DPS	E	Designated (Inland Waters)		✓	
	Southern DPS (Northern California to Mexico)	SOC[3]	Not Designated	✓		
Cowcod Rockfish (*Sebastes levis*)	Central Oregon to central Baja California and Guadalupe Island, Mexico	SOC[3]	Not Designated	✓		
Yelloweye Rockfish (*Sebastes ruberrimus*)	Puget Sound/Georgia Basin DPS	T	Designated (Inland Waters)		✓	

Table 3.9-2: Status and Presence of Endangered Species Act (ESA)-Listed Fish Species, Candidate Species, and Species of Concern Found in the Northwest Training and Testing Study Area (continued)

Species Name and Regulatory Status				Presence in Study Area		
Common Name (Scientific Name)	**Distinct Population Segment (DPS)[1]/ Evolutionarily Significant Unit (ESU)[2]**	**Federal Status**	**Critical Habitat Designation**	**Offshore Area**	**Inland Waters**	**Western Behm Canal**
Other Marine Fish Species						
Basking Shark (*Cetorhinus maximus*)	Eastern North Pacific DPS	SOC[3]	Not Designated	✓		
Green Sturgeon (*Acipenser medirostris*)	Southern DPS	T	Designated (Offshore and Inland Waters)	✓	✓	
	Northern DPS	SOC[3]	Not Designated	✓	✓	
Pacific Cod (*Gadus macrocephalus*)	Salish Sea	SOC[3]	Not Designated		✓	
Pacific Eulachon (*Thaleichthys pacificus*)	Southern DPS	T	Designated (Not in Study Area[4])	✓	✓	
Pacific Hake (*Merluccius productus*)	Georgia Basin (Canada to Washington State) DPS	SOC[3]	Not Designated		✓	

[1] A species with more than one DPS can have more than one ESA listing status, as individual DPSs can be either not listed under the ESA or can be listed as an endangered, threatened, or candidate species.
[2] ESU is a population of organisms that is considered distinct for purposes of conservation.
[3] Species of Concern status does not carry any procedural or substantive protections under the ESA, but these species are included in this table for informational purposes.
[4] Critical habitat does not overlap with any of the activities because it is a freshwater designation.
Notes: Federal Status: E = Endangered, T = Threatened, SOC = Species of Concern

3.9.2.4.1 Salmonid Species

Since the publication of the 2015 NWTT Final EIS/OEIS, critical habitat for two species listed as threatened, the Lower Columbia River coho Salmon ESU and Puget Sound Steelhead DPS, was designated (81 FR 9251). In 2016, five-year status review updates for all Pacific salmon and steelhead were published with no changes in listing status warranted for any of the listed salmon and steelhead (National Marine Fisheries Service, 2016). In addition, the listing status under the ESA of hatchery programs associated with 28 salmon ESUs and steelhead DPSs was reviewed in Jones (2015). The origin of each hatchery population and its divergence level from the source population was evaluated in determining removal from or addition to an ESU/DPS. Coded wire tagging (National Marine Fisheries Service, 2003; Weitkamp, 2010) and genetic analysis (Beacham et al., 2016; Tucker et al., 2012) has identified six Chinook salmon ESUs (Puget Sound, Upper Columbia River spring-run, Lower Columbia River, Upper Willamette River, Snake River spring/summer-run, and Snake River fall-run) and three coho salmon ESUs (Puget Sound, Lower Columbia River, and Oregon Coast) with a potential of occurring in the vicinity of the Western Behm Canal. In addition, Teel et al. (2015) used microsatellite DNA data and genetic stock identification methods to describe coastal distributions of juvenile Chinook salmon between central Oregon and northern Washington. Recent literature has also documented toxic stormwater runoff as a species-specific threat to coho salmon in urbanized areas (Feist et al., 2017; McIntyre et al., 2018). With the exception of these recent changes in designated critical habitat, salmonid presence in Western Behm Canal, species-specific threats to coho salmon, or the inclusion/exclusion of hatchery populations in ESUs/DPSs, the information presented in the 2015 NWTT Final EIS/OEIS remains valid.

3.9.2.4.1.1 Chinook Salmon (Oncorhynchus tshawytscha)

A map of critical habitat designated for Puget Sound Chinook salmon in the Study Area was provided in Figure 3.9-1 of the 2015 NWTT Final EIS/OEIS. Figure 3.9-1, displaying Chinook salmon critical habitat and DoD areas excluded or exempted for designation, is provided below.

Since the publication of the 2015 NWTT Final EIS/OEIS, the following changes have occurred in the number of hatchery programs included in five of the nine listed Chinook ESUs (Jones, 2015): Upper Columbia River (decrease from 6 to 5), Lower Columbia River (decrease from 17 to 14), Upper Willamette River (decrease from 7 to 6), Snake River spring/summer-run (decrease from 15 to 11), and California Coastal (decrease from 6 to 0). Coded wire tag information indicates that adult Puget Sound, Lower Columbia River, Upper Willamette River, and Snake River fall-run Chinook are likely to be seasonally present in the vicinity of the Western Behm Canal (National Marine Fisheries Service, 2003; Weitkamp, 2010). Genetic analysis of juvenile Chinook sampled in the vicinity of the Western Behm Canal indicates the seasonal presence of juvenile Upper Columbia River spring-run, Upper Willamette River, and Snake River spring/summer-run Chinook (Tucker et al., 2012). Teel et al. (2015) found that in Oregon and Washington coastal waters, Columbia River system spring yearling Chinook were typically more abundant in May than June, and by June were largely more abundant off the northern Washington coastal waters relative to the Columbia River plume. Fall subyearling Chinook were relatively absent in May but were more prevalent in June and September. Teel et al. (2015) also noted that a number of studies documented that selected spring juveniles quickly migrate from Oregon and Washington coastal waters northward until they reach Alaskan coastal waters in the summer, before moving off the continental shelf by fall (Fisher et al., 2014; Orsi et al., 2000; Trudel et al., 2009; Tucker et al., 2011). With the exception of the changes in hatchery programs included in the five ESUs and species presence in the Western Behm Canal and the addition of the U.S. Navy lands and Navy security zones exempted or excluded from critical habitat, the information presented in the 2015 NWTT Final EIS/OEIS remains valid.

3.9.2.4.1.2 Coho Salmon (*Oncorhynchus kisutch*)

Since the publication of the 2015 NWTT Final EIS/OEIS, critical habitat for the Lower Columbia River coho ESU, listed as threatened, was designated (81 FR 9251). However, the critical habitat designation only includes the Lower Columbia River system and does not include the Study Area. The following changes have occurred in the number of hatchery programs included in two of the four listed coho ESUs (Jones, 2015): Lower Columbia River (decrease from 25 to 21) and Central California Coast (decrease from 4 to 2).

Genetic analysis of juvenile coho salmon sampled in the vicinity of the Western Behm Canal indicates the seasonal presence of juvenile Lower Columbia River, Oregon Coast, and Puget Sound coho salmon (Beacham et al., 2016). New information has documented a species-specific threat to coho salmon in the form of toxic stormwater runoff in urbanized regions creating recurrent prespawn die-offs of adult coho spawners (Feist et al., 2017; McIntyre et al., 2018). With the exception of the designation of critical habitat for the Lower Columbia River coho ESU, the changes in hatchery programs included in the two ESUs, species presence in the Western Behm Canal, and the new species-specific threat, the information presented in the 2015 NWTT Final EIS/OEIS remains valid.

3.9.2.4.1.3 Chum Salmon (*Oncorhynchus keta*)

Since the publication of the 2015 NWTT Final EIS/OEIS, the following changes have occurred in the number of hatchery programs included in the two listed chum ESUs (Jones, 2015): Hood Canal summer-run (decrease from 8 to 4) and Columbia River (decrease from 3 to 2).

Critical Habitat for the Hood Canal summer-run chum ESU in the Study Area is presented in Figure 3.9-2. In the 2015 NWTT Final EIS/OEIS, exempted or excluded U.S. Navy lands and Navy security zones were not included on Figure 3.9-2. The sites below mean lower low water exempted or excluded from the Puget Sound Chinook salmon critical habitat in Section 3.9.2.4.1.1 [Chinook Salmon (*Oncorhynchus tshawytscha*)] of this document are also excluded from Hood Canal summer-run chum critical habitat.

With the exception of the changes in hatchery programs included in the two ESUs and the exempted/excluded Hood Canal summer-run chum critical habitat, the information presented in the 2015 NWTT Final EIS/OEIS remains valid.

3.9.2.4.1.4 Sockeye Salmon (*Oncorhynchus nerka*)

Since the publication of the 2015 NWTT Final EIS/OEIS, the number of hatchery programs included in the Lake Ozette sockeye ESU decreased from 2 to 1 (Jones, 2015). With the exception of the reduction in hatchery programs included in the Lake Ozette sockeye ESU, the information presented in the 2015 NWTT Final EIS/OEIS remains valid.

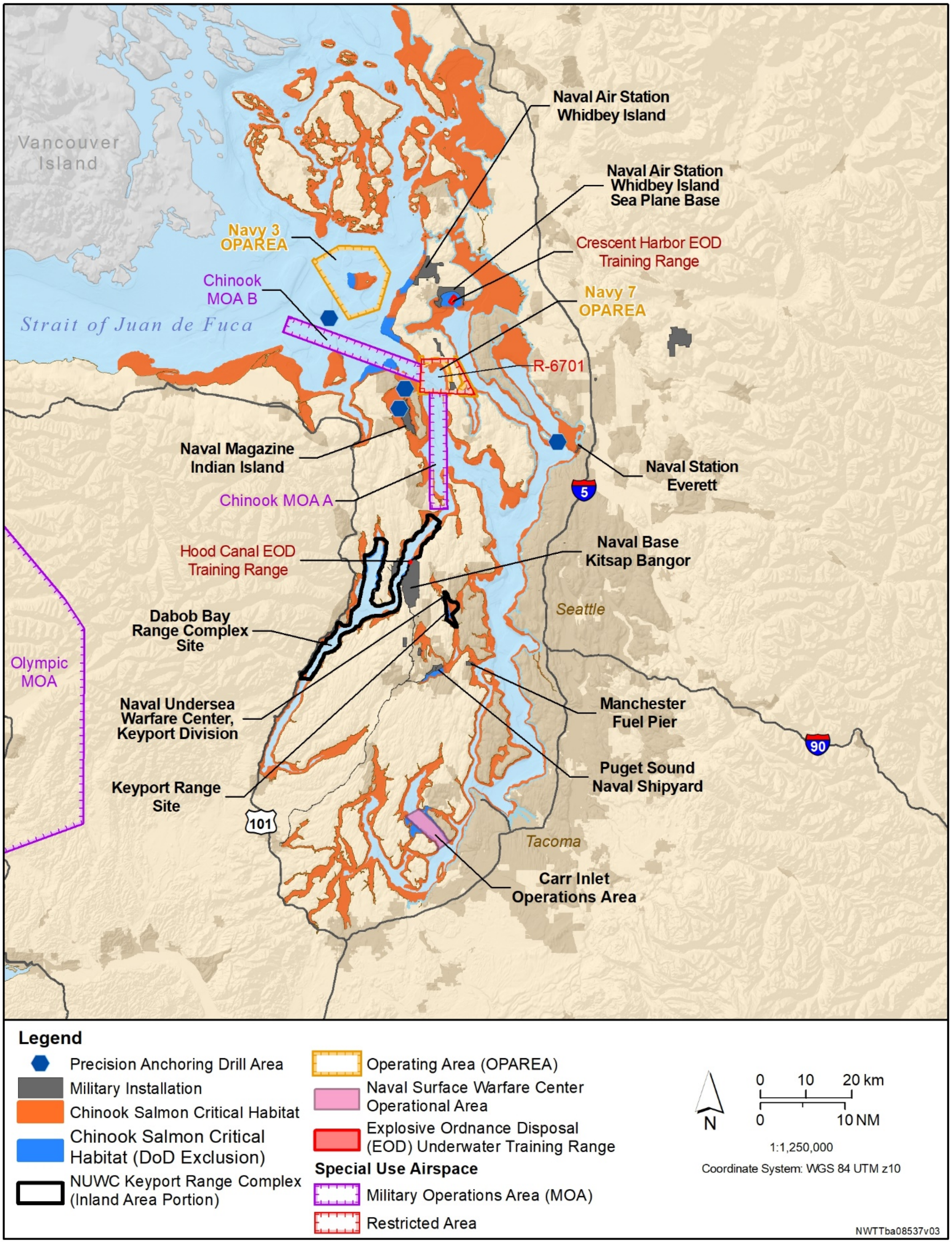


Figure 3.9-1: Marine Critical Habitat for the Puget Sound Chinook Salmon Evolutionarily Significant Units

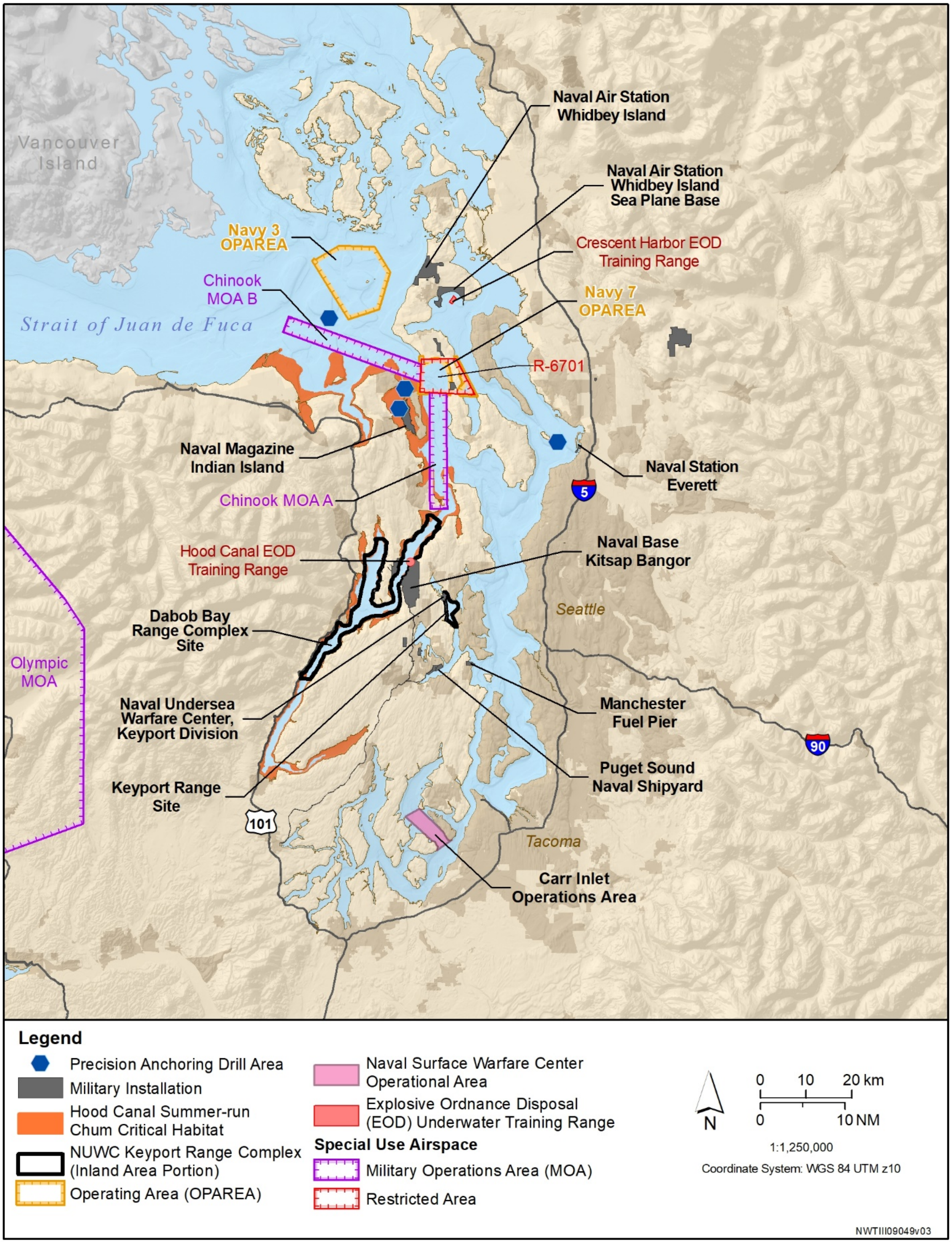


Figure 3.9-2: Marine Critical Habitat for the Hood Canal Summer-Run Chum Salmon Evolutionarily Significant Units

3.9.2.4.1.5 Steelhead (*Oncorhynchus mykiss*)

Since the publication of the 2015 NWTT Final EIS/OEIS, critical habitat for the Puget Sound Steelhead DPS, listed as threatened, was designated (81 FR 9251). However, critical habitat for this DPS has only been designated in freshwater and estuarine areas outside of the Study Area. There is no critical habitat for steelhead in the Study Area.

The following changes have occurred in the number of hatchery programs included in 8 of the 11 listed steelhead salmon DPSs (Jones, 2015): Puget Sound (increase from 2 to 6), Upper Columbia River (decrease from 6 to 5), Lower Columbia River (decrease from 10 to 7), Upper Willamette River (increase from 0 to 1), Snake River Basin (increase from 6 to 7), Northern California (decrease from 2 to 1), California Central Valley (increase from 0 to 2), and Central California Coast (increase from 0 to 2). With the exception of the designation of critical habitat for the Puget Sound Steelhead DPS and the changes in hatchery programs included/excluded in the eight DPSs, the information presented in the 2015 NWTT Final EIS/OEIS remains valid.

3.9.2.4.1.6 Bull Trout (*Salvelinus confluentus*)

A map of critical habitat designated for bull trout in the Study Area is provided in Figure 3.9-3. Figure 3.9-3 displays designated marine bull trout critical habitat, including areas excluded or exempted for the DoD, Habitat Conservation Plans (HCPs), or tribes.

Bull trout are managed as a single DPS, and the former Coastal-Puget Sound Bull Trout DPS has been incorporated into part of the Coastal Recovery Unit (U.S. Fish and Wildlife Service, 2015). A literature review indicates that individual bull trout have been documented to switch between fluvial and anadromous life histories in alternate years (Goetz, 2016). Bull trout in marine waters are shoreline-oriented (Goetz, 2016) and enter marine water for the primary purpose of foraging on smaller fish in the intertidal and subtidal zones of the photic zone, primarily in water less than 10 m in depth. Prey species may include surf smelt, sand lance, juvenile herring, shiner perch, three-spine stickleback, and juvenile salmonids (Goetz, 2016; Goetz et al., 2004).

Acoustic tagged bull trout in Puget Sound are usually detected less than 0.4 kilometers (km) from the shoreline in water less than 4 m deep (Goetz, 2016; Hayes et al., 2011). Bull trout occasionally enter water up to 25 m in depth (Goetz et al., 2004); to transit to the shoreline of Whidbey Island, they must cross Skagit Bay in waters 7–84 m in depth (Goetz, 2016). On a few rare occasions, bull trout have been tracked crossing water up to 250 m deep for as far as 6.9 km (Goetz, 2016), but do not maintain position in deep water and soon return to shallower water(Hayes et al., 2011).

Puget Sound anadromous bull trout enter marine waters in early spring, with residence time in salt water averaging two months, with a maximum of four months (Goetz, 2016). Anadromous bull trout on the Olympic coast of Washington State enter their natal streams at about the same time as Puget Sound bull trout (late spring and early summer), but overwinter in the Pacific Ocean or migrate through marine water to non-natal rain-fed streams, optimizing winter refugia and forage opportunities (Brenkman & Corbett, 2005; Goetz, 2016). The radiotelemetry studies conducted by Brenkman and Corbett (2005) revealed that adult bull trout moved between freshwater and the Pacific Ocean and between watersheds along coastal Washington. Radio signals did not transmit while fish occupied saltwater but resumed transmission when fish reentered an estuary and freshwater. In 2019, 17 bull trout were tagged by NMFS with VEMCO acoustic tags to better understand their marine distribution as part of a Navy-funded monitoring project (Matsubu, 2019; Smith & Huff, 2020). Eleven bull trout were tagged in Kalaloch Creek and six bull trout were tagged in the Hoh River. Eight of the Kalaloch Creek tagged fish

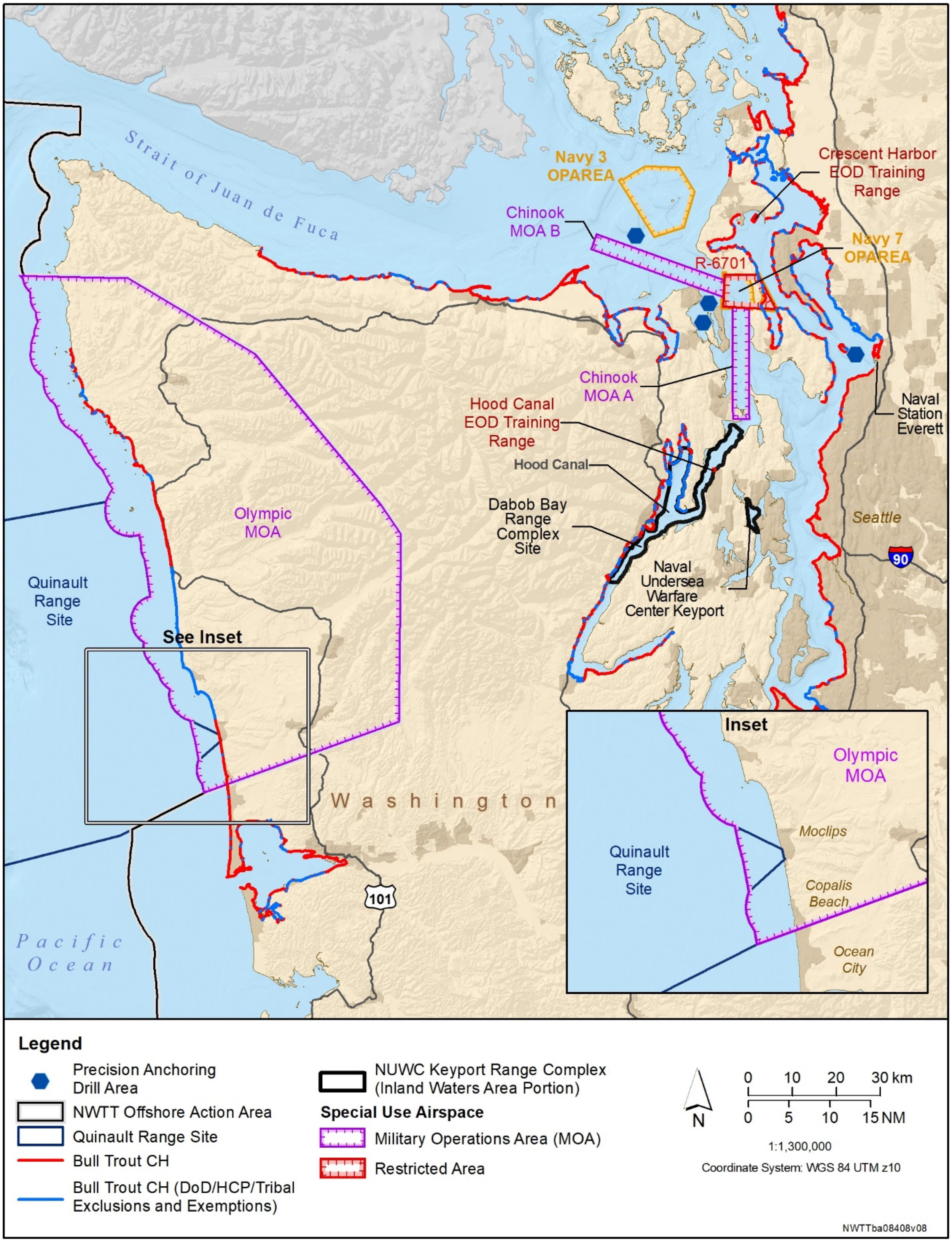


Figure 3.9-3: Marine Critical Habitat for the Bull Trout Distinct Population Segment

were later detected in the Quinault River and one Kalaloch Creek fish was detected in the Quileute River. A single bull trout that was tagged in Kalaloch Creek was detected within the offshore portion of the Study Area (Smith & Huff, 2020).The only other reports of captured bull trout along the Washington coast are from recreational anglers targeting surf perch in the surf zone (Brenkman, 2017).

The information on bull trout in the Study Area confirms the strong shoreline orientation of bull trout but has not substantially changed the conclusions of the 2015 NWTT Final EIS/OEIS. With the exception of the addition of DoD land exempted from critical habitat and Navy security zones, land subject to HCPs, and tribal land excluded from critical habitat, the information presented in the 2015 NWTT Final EIS/OEIS remains valid.

3.9.2.4.1.7 Dolly Varden (*Salvelinus malma*)

A literature review indicates that Washington State populations of Dolly Varden have not been documented to exhibit an anadromous life history and are not found in marine waters within the Study Area. The only Washington State population of Dolly Varden not isolated above a barrier is a population in a small headwater tributary of the upper Quinault River with a resident life history (Goetz et al., 2004). The information on Dolly Varden in the Study Area has not substantially changed the conclusions of the 2015 NWTT Final EIS/OEIS. Dolly Varden are not listed as threatened in Washington State and are not present in marine waters in the Study Area. With the exception that Dolly Varden do not occur in the Study Area, the information presented in the 2015 NWTT Final EIS/OEIS remains valid; however, the inclusion of a species absent from the Study Area was in error.

3.9.2.4.2 Rockfish Species

A map of critical habitat designated for the Puget Sound/Georgia Basin DPSs of the bocaccio, and yelloweye rockfish in the Study Area is provided below in Figure 3.9-4. Since the publication of the 2015 NWTT Final EIS/OEIS, the Puget Sound/Georgia Basin canary rockfish DPS has been delisted and designated critical habitat removed (82 FR 7711). Figure 3.9-4, displaying designated bocaccio and yelloweye rockfish critical habitat, including areas excluded or exempted for the DoD, HCPs, or tribes, is provided below.

A literature review found that the information on bocaccio and yelloweye rockfish in the Study Area has not substantially changed from what is included in the 2015 NWTT Final EIS/OEIS. With the exception of the addition of the U.S. Navy lands and Navy security zones exempted or excluded from critical habitat, the information presented in the 2015 NWTT Final EIS/OEIS remains valid.

3.9.2.4.2.1 Bocaccio (*Sebastes paucispinis*)

A literature review found that the information on the Puget Sound/Georgia Basin and Southern DPSs of the bocaccio rockfish in the Study Area has not substantially changed from what is included in the 2015 NWTT Final EIS/OEIS. Additional information was added for U.S. Navy security zones not included as critical habitat on Figure 3.9-4. Therefore, the information presented in the 2015 NWTT Final EIS/OEIS remains valid.

3.9.2.4.2.2 Canary Rockfish (*Sebastes pinniger*)

Since the publication of the 2015 NWTT Final EIS/OEIS, the Puget Sound/Georgia Basin DPS of the canary rockfish has been delisted and designated critical habitat removed (82 FR 7711). These actions were based on newly obtained samples and genetic analysis that demonstrated that the Puget Sound/Georgia Basin canary rockfish population does not meet the DPS criteria and therefore does not qualify for listing under the ESA. Therefore, the ESA status and designated critical habitat information presented in the

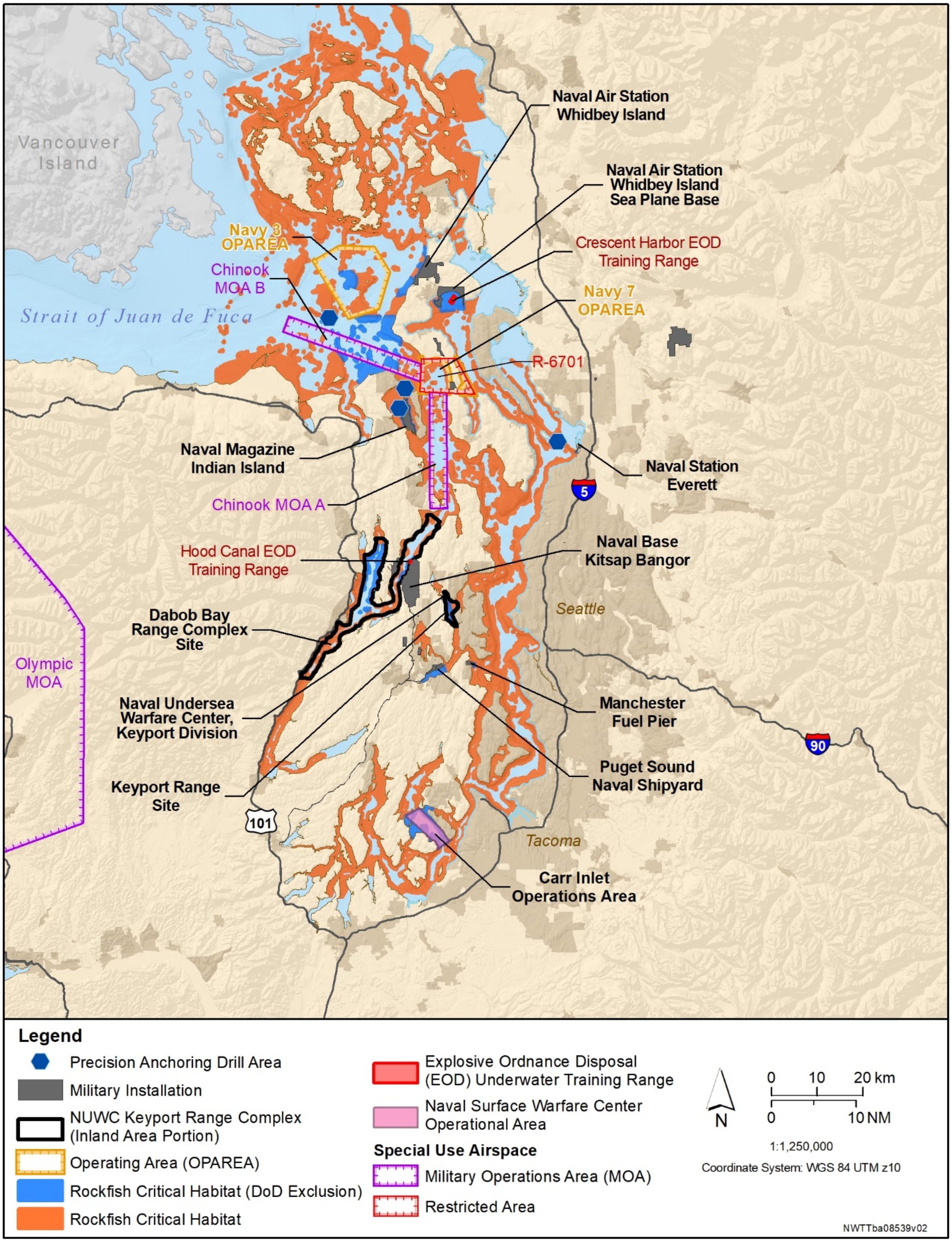


Figure 3.9-4: Critical Habitat for the Bocaccio and Yelloweye Rockfish Distinct Population Segments

2015 NWTT Final EIS/OEIS is no longer valid. Since the canary rockfish is no longer listed as federally threatened in the Study Area, it is not further addressed as an ESA listed species in this Supplemental.

3.9.2.4.2.3 Yelloweye Rockfish (*Sebastes ruberrimus*)

A literature review found that the information on the Puget Sound/Georgia Basin DPS of the yelloweye rockfish in the Study Area has not substantially changed from what is included in the 2015 NWTT Final EIS/OEIS. Additional information was added for U.S. Navy security zones not included as critical habitat on Figure 3.9-4. Therefore, the information presented in the 2015 NWTT Final EIS/OEIS remains valid.

3.9.2.4.3 Other Species

A literature review found that the information on other fish species in the Study Area has not substantially changed from what is included in the 2015 NWTT Final EIS/OEIS.

Since the publication of the 2015 NWTT Final EIS/OEIS, a status review (81 FR 18980) of the bigeye thresher shark (*Alopias supercilious*) and common thresher shark (*Alopias vulpinus*) and a status review (81 FR 41934) of the smooth hammerhead shark determined that listing of these candidate species was unwarranted. Therefore, the candidate status information presented in the 2015 NWTT Final EIS/OEIS is no longer valid and bigeye and common thresher sharks and the smooth hammerhead shark are not addressed as ESA candidate species further in this Supplemental.

3.9.2.4.3.1 Pacific Eulachon (*Thaleichthys pacificus*)

A literature review found that the information on the Southern DPS of Pacific eulachon in the Study Area has not substantially changed from what is included in the 2015 NWTT Final EIS/OEIS. Therefore, the information presented in the 2015 NWTT Final EIS/OEIS remains valid.

3.9.2.4.3.2 Green Sturgeon (*Acipenser medirostris*)

A map of critical habitat designated for green sturgeon in the Study Area was provided in Figure 3.9-3 of the 2015 NWTT Final EIS/OEIS. Figure 3.9-5, displaying green sturgeon critical habitat and DoD areas excluded or exempted for designation, is provided below.

NMFS (2009) determined that the Strait of Juan de Fuca and Whidbey Island Naval Restricted Area, Strait of Juan de Fuca Naval Air-to-Surface Weapon Range Restricted Area, Admiralty Inlet Naval Restricted Area, and Navy 3 Operating area are excluded from designated green sturgeon critical habitat. NMFS (2009) also determined that six Naval facilities with INRMPs overlap with the specific areas under consideration for critical habitat designation (all located in Puget Sound, WA). These installations include Bremerton Naval Hospital, Naval Air Station Everett, Naval Magazine Indian Island, Naval Fuel Depot Manchester, Naval Undersea Warfare Center Keyport, and Naval Air Station, Whidbey Island. The INRMPs from these facilities provide measures that would benefit green sturgeon and are therefore not eligible for designation as critical habitat.

A literature review found new information on the Southern DPS of the North American green sturgeon in the Study Area. Smith & Huff (2020) detected 124 green sturgeon at nearshore receiver locations.

3.9.2.5 Federally Managed Fisheries

Descriptions of Essential Fish Habitat (EFH) were presented in the 2015 NWTT Final EIS/OEIS. This Supplemental addresses the same activities within the Study Area that were addressed in the 2015 NWTT Final EIS/OEIS. The Pacific Fishery Management Council (Council) has four Fishery Management Plans (FMPs) in effect for the Groundfish, Coastal Pelagic, Highly Migratory, and Salmon Fishery Species

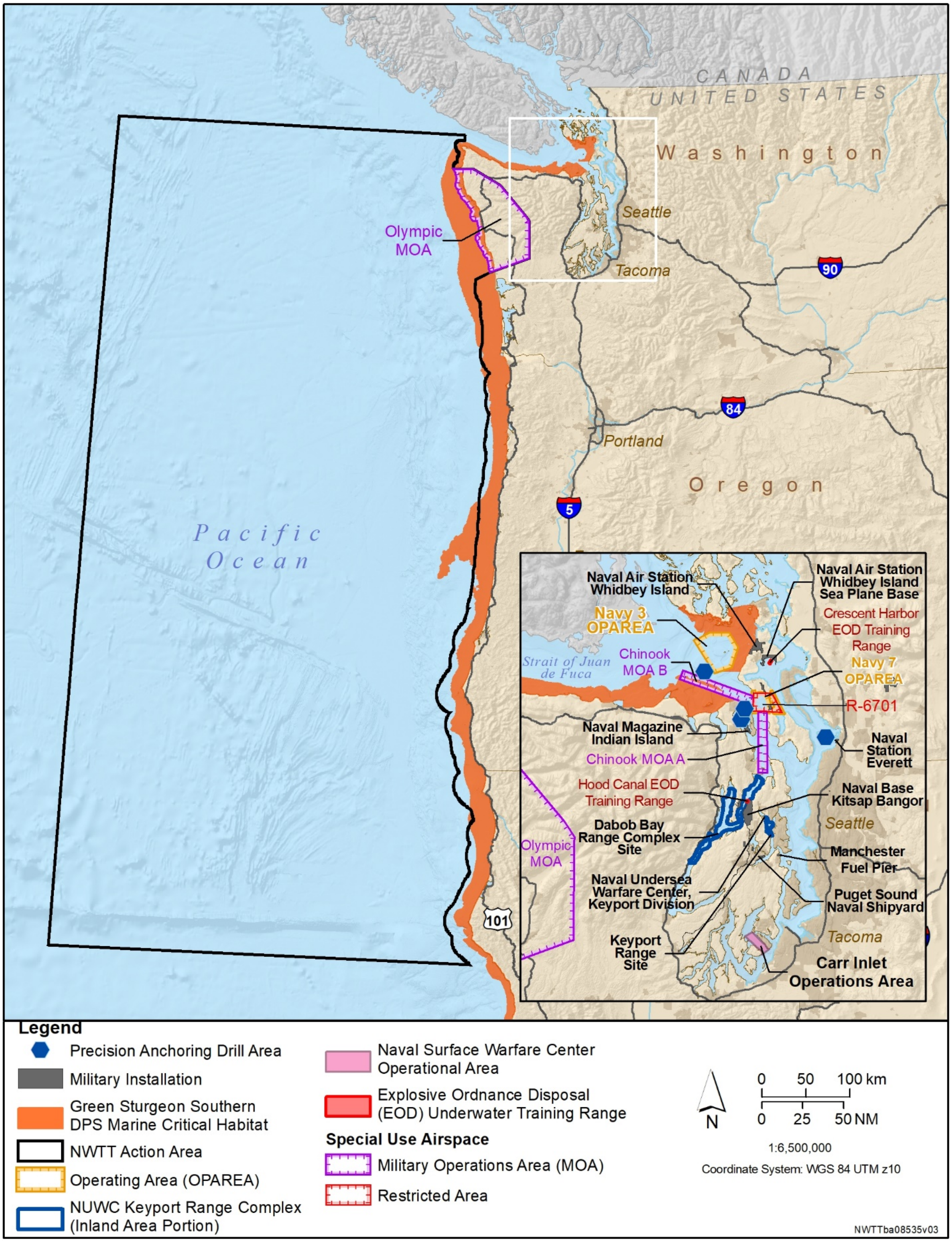


Figure 3.9-5: Critical Habitat for the Southern Distinct Population Segment of North American Green Sturgeon

in the Study Area. Although a few updates have occurred to the FMPs since the 2015 NWTT Final EIS/OEIS, none has changed or affected the previous information or analyses. As such, the general description of the EFH within the Study Area in the 2015 NWTT Final EIS/OEIS has not changed; thus, the information presented remains valid.

3.9.2.5.1 Groundfish Fishery Management Plan

As presented in the 2015 NWTT Final EIS/OEIS, the Pacific Fishery Management Plan has a Groundfish FMP. A recent review of the FMP and associated documents indicated that in June 2016, the Council adopted Amendment 27 to the plan, which reclassified big skate from an Ecosystem Component (EC) species to “in the fishery,” listed deacon rockfish in Table 3-1, and revised Chapter 5.5 to describe a new in-season process in California, which would occur outside of a Council meeting and allow NMFS to take action based upon attainment or projected attainment of Federal harvest limits of black rockfish, canary rockfish, and yelloweye rockfish. Additionally, updates to the FMP were made to clarify matters from Amendment 23 and acknowledge the successful rebuilding of canary rockfish and petrale sole. Since these amendments were included to help facilitate a sustainable groundfish fishery by reducing overall catch and did not impose new environmental baseline restrictions, the information in the 2015 NWTT Final EIS/OEIS remains valid. Therefore, no additional update to the 2015 NWTT Final EIS/OEIS is required.

3.9.2.5.2 Coastal Pelagic Fishery Management Plan

As presented in the 2015 NWTT Final EIS/OEIS, the Pacific Fishery Management Plan has a Coastal Pelagic FMP. A recent review of the FMP and associated documents indicated that no additional amendments to the plan have been adopted. Since additional amendments to the plan have not been adopted, the information in the 2015 NWTT Final EIS/OEIS remains valid. Therefore, no additional update to the 2015 NWTT Final EIS/OEIS is required.

3.9.2.5.3 Highly Migratory Fishery Management Plan

As presented in the 2015 NWTT Final EIS/OEIS, the Pacific Fishery Management Plan has a Highly Migratory FMP. A recent review of the FMP and associated documents indicated that the Council has adopted or proposed three amendments to the plan. Amendment 3, adopted in 2015, added a suite of lower trophic level species to the FMP’s list of EC species. Consistent with the objectives of the Council’s FMPs and its Fishery Ecosystem Plan, Amendment 3 prohibits future development of directed commercial fisheries for the suite of EC species shared between all four FMPs (“Shared EC Species”) until and unless the Council has had an adequate opportunity to both assess the scientific information relating to any proposed directed fishery and consider potential impacts on existing fisheries, fishing communities, and the greater marine ecosystem. In March 2017, the Council was presented with proposed amendments, but did not finalize changes to the Highly Migratory Species FMP that would revise dated and inaccurate text as Amendment 4. Also in March 2017, the Council took final action to adopt Amendment 5 to the Fishery Management Plan for West U.S. Coast Fisheries for Highly Migratory Species. This amendment would create a Federal limited entry permit for the California large mesh drift gillnet fishery. Since these amendments did not impose new environmental baseline restrictions, the information in the 2015 NWTT Final EIS/OEIS remains valid. Therefore, no additional update to the 2015 NWTT Final EIS/OEIS is required.

3.9.2.5.4 Salmon Fishery Management Plan

As presented in Section 3.9.2.5.5 of the 2015 NWTT Final EIS/OEIS, the Pacific Fishery Management Council has a Pacific Coast Salmon FMP that manages chinook, coho, and pink (*Oncorhynchus gorbuscha*) salmon. A recent review of the FMP and associated documents indicated that one additional amendment to the plan was adopted in 2016 (Pacific Fishery Management Council, 2016). The new amendment added a suite of lower trophic level species to the FMP's list of Ecosystem Component species. The amendment also prohibits future development of commercial fisheries for those Ecosystem Component species that are shared between all four FMPs (e.g., round herring, Pacific sand lance, smelts, Pelagic squids) until the Council has had an adequate opportunity to assess both the scientific information relating to any proposed directed fishery and potential impacts on existing fisheries, fishing communities, and the greater marine ecosystem. Even though an additional amendment to the plan was adopted, the information in the 2015 NWTT Final EIS/OEIS remains valid. Therefore, no additional update to the 2015 NWTT Final EIS/OEIS is required.

3.9.3 Environmental Consequences

In the Proposed Action for this Supplemental, some modifications have been made to the quantity and type of acoustic stressors under the two action alternatives. Because of new activities being proposed, two new stressors would be introduced that could potentially affect marine species; high-energy lasers (as an Energy stressor), as detailed in Section 3.0.3.3.2.2 (High-Energy Lasers), and biodegradable polymer (as an Entanglement stressor), as detailed in Section 3.0.3.5.3 (Biodegradable Polymer).

The 2015 NWTT Final EIS/OEIS considered training and testing activities proposed to occur in the Study Area that may have the potential to impact marine fishes. The stressors applicable to marine fishes in the Study Area include the two new stressors as well as the same stressors considered in the 2015 NWTT Final EIS/OEIS:

- Acoustic (sonar and other transducers, vessel noise, aircraft noise, weapon noise)
- Explosives (in-air explosions, in-water explosions)
- Energy (in-water electromagnetic devices, high-energy lasers)
- Physical disturbance and strike (vessels and in-water devices, military expended materials, seafloor devices)
- Entanglement (wires and cables, decelerators/parachutes, biodegradable polymer)
- Ingestion (military expended materials – munitions and military expended materials – other than munitions)
- Secondary (impacts on habitat and impacts on prey availability)

This section evaluates how and to what degree potential impacts on marine fishes from stressors described in Section 3.0.1 (Overall Approach to Analysis) may have changed since the analysis presented in the 2015 NWTT Final EIS/OEIS was completed. Tables 2.5-1, 2.5-2, and 2.5-3 in Chapter 2 (Description of Proposed Action and Alternatives) list the proposed training and testing activities and include the number of times each activity would be conducted annually and the locations within the Study Area where the activity would typically occur under each alternative. The tables also present the same information for activities described in the 2015 NWTT Final EIS/OEIS so that the proposed levels of training and testing under this Supplemental can be easily compared.

The Navy conducted a review of federal and state regulations and standards relevant to marine fishes and reviewed scientific literature published since 2015 for new information on marine fishes that could update the analysis presented in the 2015 NWTT Final EIS/OEIS. The analysis presented in this section also considers standard operating procedures (see Section 2.3.3, Standard Operating Procedures) and mitigation measures that the Navy would implement to avoid potential impacts on marine fishes from stressors associated with the proposed training and testing activities (see Appendix K, Geographic Mitigation Assessment, for more details). Mitigation for marine fishes will be coordinated with NMFS through the ESA consultation process.

3.9.3.1 Acoustic Stressors

The analysis of effects to fishes follows the concepts outlined in Section 3.0.3.7 (Conceptual Framework for Assessing Effects from Acoustic and Explosive Activities). This section begins with a summary of relevant data regarding acoustic impacts on fishes in Section 3.9.3.1.1 (Background). This is followed by an analysis of estimated impacts on fishes due to specific Navy acoustic stressors (sonar and other transducers, vessel noise, aircraft noise, and weapon noise). Additional explanations of the acoustic terms and sound energy concepts used in this section are found in Appendix D (Acoustic and Explosive Concepts).

The Navy will rely on the previous 2015 NWTT Final EIS/OEIS analysis for the analysis of vessel noise, and weapon noise, as there has been no substantive or otherwise meaningful change in the action, although new applicable and emergent science in regard to these sub-stressors is presented in the sections that follow. Due to available new literature, adjusted sound exposure criteria, and new acoustic effects modeling, the analysis provided in Section 3.9.3.1.2 (Impacts from Sonar and Other Transducers) and Section 3.9.3.1.4 (Impacts from Aircraft Noise) of this Supplemental supplants the 2015 NWTT Final EIS/OEIS for fishes, and changes estimated impacts for some species since the 2015 NWTT Final EIS/OEIS.

3.9.3.1.1 Background

Effects of human-generated sound on fishes have been examined and summarized in numerous publications (de Jong et al., 2020; Hastings & Popper, 2005; Hawkins et al., 2015; Ladich & Popper, 2004; Lindseth & Lobel, 2018; Mann, 2016; Mickle & Higgs, 2018; National Research Council, 1994, 2003; Neenan et al., 2016; Popper & Hawkins, 2019; Popper, 2003, 2008; Popper et al., 2016; Popper & Hastings, 2009b; Popper & Hawkins, 2018; Popper et al., 2014). The potential impacts from Navy activities are based on the analysis of available literature related to each type of effect. Where applicable, interim criteria and thresholds and relative risk factors presented in the *ANSI Sound Exposure Guideline* technical report (Popper et al., 2014) were used to assist in the analysis of effects on fishes from Navy activities.

There are limited studies of fish responses to aircraft and weapon noise. Based on the general characteristics of these sound types, for stressors where data is lacking (such as aircraft noise), studies of the effects of similar non-impulsive/continuous noise sources (such as sonar or vessel noise) are used to inform the analysis of fish responses. Similarly, studies of the effects from impulsive sources (such as air guns or pile driving) are used to inform fish responses to other impulsive sources (such as weapon noise). Non-impulsive or continuous sources may be presented as a proxy source to better understand potential reactions from fish where data from sonar and vessel noise exposures are limited. Additional information on the acoustic characteristics of these sources can be found in Appendix D (Acoustic and Explosive Concepts).

Although air guns and pile driving are not used during NWTT training and testing activities, the analysis of some explosive impacts (Section 5.4.2, Explosive Stressors) will in part rely on data from fishes exposed to impulsive sources where appropriate. Therefore, background information on impulsive sources are provided below.

3.9.3.1.1.1 Injury

Injury refers to the direct effects on the tissues or organs of a fish. Moderate- to low-level noise from vessels, aircraft, and weapons use are described in Section 3.0.3.1 (Acoustic Stressors) and lacks the amplitude and energy to cause any direct injury. Section 3.0.3.7 (Conceptual Framework for Assessing Effects from Acoustic and Explosive Activities) provides additional information on injury and the framework used to analyze this potential impact.

Injury due to Impulsive Sound Sources

Impulsive sounds, such as those produced by seismic air guns and impact pile driving, may cause injury or mortality in fishes. Although air guns and pile driving would not occur in the Study Area, this information aids in the analysis of other impulsive sources (i.e., weapons noise or in some cases, explosions). Mortality and potential damage to the cells of the lateral line have been observed in fish larvae, fry, and embryos after exposure to single shots from a seismic air gun within close proximity to the sound source (0.1 to 6 m) (Booman et al., 1996; Cox et al., 2012). However, exposure of adult fish to a single shot from an air gun array (four air guns) within similar ranges (6 m), has not resulted in any signs of mortality within seven days after exposure (Popper et al., 2016). Although injuries occurred in adult fishes, they were similar to injuries seen in control subjects (i.e., fishes that were not exposed to the air gun) so there is little evidence that the air gun exposure solely contributed to the observed effects.

Injuries, such as ruptured swim bladders, hematomas, and hemorrhaging of other gas-filled organs, have been reported in fish exposed to a large number of simulated impact pile driving strikes with cumulative sound exposure levels up to 219 dB referenced to 1 micropascal squared seconds (dB re 1 µPa^2-s) under highly controlled settings where fish were unable to avoid the source (Casper et al., 2013a; Casper et al., 2012b; Casper et al., 2013b; Halvorsen et al., 2012a; Halvorsen et al., 2011, 2012b). However, it is important to note that these studies exposed fish to 900 or more strikes as the studies aimed to evaluate the equal energy hypothesis, which suggests that the effects of a large single pulse of energy is equivalent to the effects of energy received from many smaller pulses (as discussed in Smith & Gilley, 2008). Halvorsen et al. (2011) and Casper et al. (2017) found that the equal energy hypothesis does not apply to effects of pile driving; rather, metrics relevant to injury could include, but not be limited to, cumulative sound exposure level, single strike sound exposure level, and number of strikes (Halvorsen et al., 2011). Furthermore, Casper et al. (2017) found the amount of energy in each pile strike and the number of strikes determines the severity of the exposure and the injuries that may be observed. For example, hybrid striped bass (white bass *Morone chrysops* x striped bass *M. saxatilis*) exposed to fewer strikes with higher single strike sound exposure values resulted in a higher number of, and more severe, injuries than bass exposed to an equivalent cumulative sound exposure level that contained more strikes with lower single strike sound exposure values. This is important to consider when comparing data from pile driving studies to potential effects from an explosion. Although single strike peak sound pressure levels were measured during these experiments (at average levels of 207 dB re 1 µPa), the injuries were only observed during exposures to multiple strikes; therefore, it is anticipated that a peak value much higher than the reported values would be required to lead to injury in fishes exposed to a single strike or explosion.

These studies included species both with and without swim bladders. The majority of fish that exhibited injuries were those with swim bladders. Lake sturgeon (*Acipenser fulyescens*), a physostomous fish, was found to be less susceptible to injury from impulsive sources than Nile tilapia (*Oreochromis niloticus*) or hybrid striped bass, physoclistous fishes (Casper et al., 2017; Halvorsen et al., 2012a). As reported by Halvorsen et al. (2012a), the difference in results is likely due to the type of swim bladder in each fish. Physostomous fishes have an open duct connecting the swim bladder to their esophagus and may be able to quickly adjust the amount of gas in their body by gulping or releasing air. Physoclistous fishes do not have this duct; instead, special tissues or glands regulate gas pressure in the swim bladder. There were no mortalities reported during these experiments, and in the studies where recovery was observed, the majority of exposure related injuries healed within a few days in a laboratory setting. In many of these controlled studies, neutral buoyancy was determined in the fishes prior to exposure to the simulated pile driving. However, fishes with similar physiology to those described in these studies that are exposed to actual pile driving activities may show varying levels of injury depending on their state of buoyancy.

By exposing caged juvenile European sea bass (*Dicentrarchus labrax*) to actual pile driving operations, Debusschere et al. (2014) confirmed the results discussed in the paragraph above. No differences in mortality were found between control and experimental groups at similar levels tested in the experiments described in the paragraph above (sound exposure levels up to 215–222 dB re 1 μPa^2-s), and many of the same types of injuries occurred (Casper et al., 2013a; Casper et al., 2012b; Casper et al., 2013b; Halvorsen et al., 2012a; Halvorsen et al., 2011, 2012b). Fishes with injuries from impulsive sources such as these may not survive in the wild due to harsher conditions and risk of predation.

Other potential effects from exposure to impulsive sound sources include potential bubble formation and neurotrauma. It is speculated that high sound pressure levels may also cause bubbles to form from micronuclei in the blood stream or other tissues of animals, possibly causing embolism damage (Hastings & Popper, 2005). Fishes have small capillaries where these bubbles could be caught and lead to the rupturing of the capillaries and internal bleeding. It has also been speculated that this phenomena could take place in the eyes of fish due to potentially high gas saturation within the eye tissues (Popper & Hastings, 2009b). Additional research is necessary to verify if these speculations apply to exposures to non-impulsive sources such as sonars. These phenomena have not been well studied in fishes and are difficult to recreate under real-world conditions.

As summarized in the *ANSI Sound Exposure Guideline* technical report (Popper et al., 2014), exposure to high intensity and long duration impact pile driving or air gun shots did not cause mortality, and fishes typically recovered from injuries in controlled laboratory settings. Species tested to date can be used as viable surrogates for investigating injury in other species exposed to similar sources (Popper et al., 2014).

Injury due to Sonar and Other Transducers

Non-impulsive sound sources (e.g., sonar, acoustic modems, and sonobuoys) have not been known to cause direct injury or mortality to fish under conditions that would be found in the wild (Halvorsen et al., 2012a; Kane et al., 2010; Popper et al., 2007). Potential direct injuries (e.g., barotrauma, hemorrhage or rupture of organs or tissue) from non-impulsive sound sources, such as sonar, are unlikely because of slow rise times,[1] lack of a strong shock wave such as that associated with an explosive, and relatively low peak pressures. General categories and characteristics of Navy sonar systems are described in

[1] Rise time: the amount of time for a signal to change from static pressure (the ambient pressure without the added sound) to high pressure. Rise times for non-impulsive sound typically have relatively gradual increases in pressure where impulsive sound has near-instantaneous rise to a high peak pressure. For more detail, see Appendix D (Acoustic and Explosive Concepts).

Section 3.0.3.1.1 (Sonar and Other Transducers).

The effects of mid-frequency sonar-like signals (1.5–6.5 kHz) on larval and juvenile Atlantic herring (*Clupea harengus*), Atlantic cod (*Gadus morhura*), saithe (*Pollachius virens*), and spotted wolffish (*Anarhichas minor*) were examined by Jørgensen et al. (2005). Researchers investigated potential effects on survival, development, and behavior in this study. Among fish kept in tanks and observed for one to four weeks after sound exposure, no significant differences in mortality or growth-related parameters between exposed and unexposed groups were observed. Examination of organs and tissues from selected herring experiments did not reveal obvious differences between unexposed and exposed groups. However, two (out of 42) of the herring groups exposed to sound pressure levels of 189 dB re 1 µPa and 179 dB re 1 µPa had a post-exposure mortality of 19 and 30 percent, respectively. It is not clear if this increased mortality was due to the received level or to other unknown factors, such as exposure to the resonance frequency of the swim bladder. Jørgensen et al. (2005) estimated a resonant frequency of 1.8 kHz for herring and saithe ranging in size from 6.3 to 7.0 centimeters, respectively, which lies within the range of frequencies used during sound exposures and therefore may explain some of the noted mortalities.

Individual juvenile fish with a swim bladder resonance in the frequency range of the operational sonars may be more susceptible to injury or mortality. Past research has demonstrated that fish species, size and depth influences resonant frequency (Løvik & Hovem, 1979; McCartney & Stubbs, 1971). At resonance, the swim bladder, which can amplify vibrations that reach the fish's hearing organs, may absorb much of the acoustic energy in the impinging sound wave. It is suspected that the resulting oscillations may cause mortality, harm the auditory organs or the swim bladder (Jørgensen et al., 2005; Kvadsheim & Sevaldsen, 2005b). However, damage to the swim bladder and to tissues surrounding the swim bladder was not observed in fishes exposed to sonar at their presumed swim bladder resonant frequency (Jørgensen et al., 2005). Sonar is expected to physiologically affect adult fish less than juveniles because adult fish are in a more robust stage of development, and their swim bladder resonant frequencies would be lower than that of mid-frequency active sonar. Additionally, adult fish have more ability to move from an unpleasant stimulus (Kvadsheim & Sevaldsen, 2005a). Lower frequencies (i.e., generally below 1 kHz) are expected to produce swim bladder resonance in adult fishes from about 10 to 100 centimeters (McCartney & Stubbs, 1971). Fish, especially larval and small juveniles, are more susceptible to injury from swim bladder resonance when exposed to continuous signals within the resonant frequency range.

Hastings (1991; 1995) tested the limits of acoustic exposure on two freshwater fish species. Hastings found "acoustic stunning" (loss of consciousness) in blue gouramis (*Trichogaster trichopterus*) following an eight-minute continuous exposure in captivity to a 150 Hz pure tone with a sound pressure level of 198 dB re 1 µPa (Hastings, 1995). This species of fish has an air bubble in the mouth cavity directly adjacent to the animal's braincase that may have caused this injury. Hastings (1991; 1995) also found that goldfish (*Carassius auratus*), exposed to a 250 Hz continuous wave sound with peak pressures of 204 dB re 1 µPa for two hours, and blue gourami exposed to a 150 Hz continuous wave sound at a sound pressure level of 198 dB re 1 µPa for 0.5 hour did not survive. These studies illustrate the highest known levels tested on fishes with hearing specializations. These high levels of noise were also projected for relatively long durations of time and in a small tank test environment; therefore, direct comparisons to results in natural settings should be treated with caution. Stunning and mortality due to exposure to non-impulsive sound exposure has not been observed in other studies.

Three freshwater species of fish, the rainbow trout (*Oncorhynchus mykiss,* also known as steelhead), channel catfish (*Ictalurus punctatus*), and the hybrid sunfish (*Lepomis* sp.), were exposed to both low- and mid-frequency sonar (Kane et al., 2010; Popper et al., 2007). Low-frequency exposures with received sound pressure levels of 193 dB re 1 µPa occurred for either 324 or 648 seconds. Mid-frequency exposures with received sound pressure levels of 210 dB re 1 µPa occurred for 15 seconds. No fish mortality resulted from either experiment, and during necropsy after test exposures, both studies found that none of the subjects showed signs of tissue damage related to exposure (Kane et al., 2010; Popper et al., 2007).

As summarized in the *ANSI Sound Exposure Guideline* technical report (Popper et al., 2014), although fish have been injured and killed due to intense, long-duration, non-impulsive sound exposures, fish exposed under more realistic conditions have shown no signs of injury. Those species tested to date can be used as viable surrogates for estimating injury in other species exposed to similar sources.

3.9.3.1.1.2 Hearing Loss

Researchers have examined the effects on hearing in fishes from sonar-like signals, tones, and different non-impulsive noise sources. Section 3.0.3.7 (Conceptual Framework for Assessing Effects from Acoustic and Explosive Activities) provides additional information on hearing loss and the framework used to analyze this potential impact.

Exposure to high-intensity sound can cause hearing loss, also known as a noise-induced threshold shift, or simply a threshold shift (Miller, 1974). A temporary threshold shift (TTS) is a temporary, recoverable loss of hearing sensitivity. A TTS may last several minutes to several weeks, and the duration may be related to the intensity of the sound source and the duration of the sound exposure (including multiple exposures). A permanent threshold shift (PTS) is non-recoverable, results from the destruction of tissues within the auditory system, permanent loss of hair cells, or damage to auditory nerve fibers (Liberman, 2016), and can occur over a small range of frequencies related to the sound exposure. However, the sensory hair cells of the inner ear in fishes are regularly replaced over time when they are damaged, unlike in mammals where sensory hair cell loss is permanent (Lombarte et al., 1993; Popper et al., 2014; Smith et al., 2006). Consequently, PTS has not been known to occur in fishes, and any hearing loss in fish may be as temporary as the timeframe required to repair or replace the sensory cells that were damaged or destroyed (Popper et al., 2014; Popper et al., 2005; Smith et al., 2006). As with TTS, the animal does not become deaf but requires a louder sound stimulus, relative to the amount of PTS, to detect a sound within the affected frequencies. For example, if 5 dB of PTS occurs at a certain frequency, then a sound at that same frequency would need to be 5 dB louder for the animal to detect it. Although available data for some terrestrial mammals have shown signs of nerve damage after severe threshold shifts (e.g., Kujawa & Liberman, 2009; Lin et al., 2011), it is not known if damage to auditory nerve fibers could also occur in fishes and, if so, whether fibers would recover during this process. One example that demonstrated a lack of damage to sensory receptors when TTS occurred was in a study on hearing loss in zebrafish (*Danio rerio,* a freshwater species with a swim bladder involved in hearing). This was one of the first studies to look at both auditory threshold shifts and potential physical effects on the inner ear. However, marine species have yet to be tested and future research should evaluate other potential mechanisms of cellular or structural damage if in fact physical damage occurs in fishes with the onset of a threshold shift (Breitzler et al., 2020).

Hearing Loss due to Impulsive Sound Sources

Popper et al. (2005) examined the effects of a seismic air gun array on a fish with a swim bladder that is involved in hearing, the lake chub (*Couesius plumbeus*), and two species that have a swim bladder that is not involved in hearing, the northern pike (*Esox lucius*) and the broad whitefish (*Coregonus nasus*), a salmonid. In this study, the lowest received cumulative sound exposure level at which effects were noted was 186 dB re 1 µPa^2-s (five shots with a mean sound pressure level of 177 dB re 1 µPa). The results showed temporary hearing loss for both lake chub and northern pike to both 5 and 20 air gun shots, but not for the broad whitefish. Hearing loss was approximately 20–25 dB at some frequencies for both species, and full recovery of hearing took place within 18 hours after sound exposure. Examination of the sensory surfaces of the ears after allotted recovery times (one hour for five shot exposures, and up to 18 hours for 20 shot exposures) showed no damage to sensory hair cells in any of the fish from these exposures (Song et al., 2008).

McCauley et al. (2003) and McCauley and Kent (2012) showed loss of a small percent of sensory hair cells in the inner ear of caged fish exposed to a towed air gun array simulating a passing seismic vessel. Pink snapper (*Pargus auratus*), a species that has a swim bladder that is not involved in hearing, were exposed to multiple air gun shots for up to 1.5 hours (McCauley et al., 2003) where the maximum received sound exposure levels exceeded 180 dB re 1 µPa^2-s. The loss of sensory hair cells continued to increase for up to at least 58 days post exposure to 2.7 percent of the total cells. Gold band snapper (*Pristipomoides multidens*) and sea perch (*Lutjanus kasmira*), both fishes with a swim bladder involved in hearing, were also exposed to a towed air gun array simulating a passing seismic vessel (McCauley & Kent, 2012). Although received levels for these exposures have not been published, hair cell damage increased as the range of the exposure (i.e., range to the source) decreased. Again, the amount of damage was considered small in each case (McCauley & Kent, 2012). It is not known if this hair cell loss would result in hearing loss since fish have tens or even hundreds of thousands of sensory hair cells in the inner ear and only a small portion were affected by the sound (Lombarte & Popper, 1994; Popper & Hoxter, 1984). The reason McCauley and Kent (2012) found damage to sensory hair cells, while Popper et al. (2005) did not, may be in their distinct methodologies. Their studies had many differences, including species and the precise sound source characteristics.

Hastings et al. (2008) exposed a fish with a swim bladder that is involved in hearing, the pinecone soldierfish (*Myripristis murdjan*), and three species that have a swim bladder that is not involved in hearing, the blue green damselfish (*Chromis viridis*), the saber squirrelfish (*Sargocentron spiniferum*), and the bluestripe seaperch (*Lutjanus kasmira*), to an air gun array. Fish in cages were exposed to multiple air gun shots with a cumulative sound exposure level of 190 dB re 1 µPa^2-s. The authors found no hearing loss in any fish examined up to 12 hours after the exposures.

In an investigation of another impulsive source, Casper et al. (2013b) found that some fishes may actually be more susceptible to barotrauma (e.g., swim bladder ruptures, herniations, and hematomas) than hearing effects when exposed to simulated impact pile driving. Hybrid striped bass (white bass x striped bass) and Mozambique tilapia (*Oreochromis mossambicus*), two species with a swim bladder not involved in hearing, were exposed to sound exposure levels between 213 and 216 dB re 1 µPa^2-s. The subjects exhibited barotrauma, and although researchers began to observe signs of inner ear hair cell loss, these effects were small compared to the other non-auditory injuries incurred. Researchers speculated that injury might occur prior to signs of hearing loss or TTS. These sound exposure levels may present the lowest threshold at which hearing effects may begin to occur.

Overall, PTS has not been known to occur in fishes tested to date. Any hearing loss in fish may be as temporary as the timeframe required to repair or replace the sensory cells that were damaged or destroyed (Popper et al., 2014; Popper et al., 2005; Smith et al., 2006). The lowest sound exposure level at which TTS has been observed in fishes with a swim bladder involved in hearing is 186 dB re 1 µPa^2-s. As reviewed in the *ANSI Sound Exposure Guideline* technical report (Popper et al., 2014), fishes without a swim bladder, or fishes with a swim bladder that is not involved in hearing, would be less susceptible to hearing loss (i.e., TTS) than fishes with swim bladders involved in hearing, even at higher levels and longer durations.

Hearing Loss due to Sonar and Other Transducers

Several studies have examined the effects of the sound exposures from low-frequency sonar on fish hearing (i.e., Halvorsen et al., 2013; Kane et al., 2010; Popper et al., 2007). Hearing was measured both immediately post exposure and for up to several days thereafter (Halvorsen et al., 2013; Kane et al., 2010; Popper et al., 2007). Maximum received sound pressure levels were 193 dB re 1 µPa for 324 or 648 seconds (a cumulative sound exposure level of 218 or 220 dB re 1 µPa^2-s, respectively) at frequencies ranging from 170 to 320 Hz (Kane et al., 2010; Popper et al., 2007) and 195 dB re 1 µPa for 324 seconds (a cumulative sound exposure level of 215 dB re 1 µPa^2-s) in a follow-on study (Halvorsen et al., 2013). Two species with a swim bladder not involved in hearing, the largemouth bass (*Micropterus salmoides*) and yellow perch (*Perca flavescens*), showed no loss in hearing sensitivity from sound exposure immediately after the test or 24 hours later. Channel catfish, a fish with a swim bladder involved in hearing, and some specimens of rainbow trout, a fish with a swim bladder not involved in hearing, showed a threshold shift (up to 10 to 20 dB of hearing loss) immediately after exposure to the low-frequency sonar when compared to baseline and control animals. Small thresholds shifts were detected for up to 24 hours after the experiment in some channel catfish. Although some rainbow trout in one test group showed signs of hearing loss, rainbow trout in another group showed no hearing loss. The different results between rainbow trout test groups are difficult to understand, but may be due to development or genetic differences in the various groups of fish. Catfish hearing returned to, or close to, normal within about 24 hours after exposure to low-frequency sonar. Examination of the inner ears of the fish during necropsy revealed no differences from the control groups in ciliary bundles or other features indicative of hearing loss. The maximum time fish were held post exposure before sacrifice was 96 hours (Kane et al., 2010).

The same investigators examined the potential effects of mid-frequency active sonar on fish hearing and the inner ear (Halvorsen et al., 2012c; Kane et al., 2010). The maximum received sound pressure level was 210 dB re 1 µPa at a frequency of 2.8 to 3.8 kHz for a total duration of 15 seconds (cumulative sound exposure level of 220 dB re 1 µPa^2-s). Out of the species tested (rainbow trout and channel catfish), only one test group of channel catfish showed any hearing loss after exposure to mid-frequency active sonar. The investigators tested catfish during two different seasons and found that the group tested in October experienced TTS, which recovered within 24 hours, but fish tested in December showed no effect. It was speculated that the difference in hearing loss between catfish groups might have been due to the difference in water temperature during the testing period or due to differences between the two stocks of fish (Halvorsen et al., 2012c). Any effects on hearing in channel catfish due to sound exposure appeared to be short-term and non-permanent (Halvorsen et al., 2012c; Kane et al., 2010).

Some studies have suggested that there may be some loss of sensory hair cells due to high intensity sources, indicating a loss in hearing sensitivity; however, none of those studies concurrently investigated the subjects' actual hearing range after exposure to these sources. Enger (1981) found loss of ciliary bundles of the sensory cells in the inner ears of Atlantic cod following one to five hours of exposure to pure tone sounds between 50 and 400 Hz with a sound pressure level of 180 dB re 1 µPa. Hastings (1995) found auditory hair-cell damage in goldfish, a freshwater species with a swim bladder that is involved in hearing. Goldfish were exposed to 250 Hz and 500 Hz continuous tones with maximum peak sound pressure levels of 204 dB re 1 µPa and 197 dB re 1 µPa, respectively, for about two hours. Similarly, Hastings et al. (1996) demonstrated damage to some sensory hair cells in oscars (*Astronotus ocellatus*) observed one to four days following a one-hour exposure to a pure tone at 300 Hz with a sound pressure level of 180 dB re 1 µPa, but no damage to the lateral line was observed. Both studies found a relatively small percentage of total hair cell loss from hearing organs despite long duration exposures. Effects from long-duration noise exposure studies are generally informative; however, they are not necessarily a direct comparison to intermittent short-duration exposures produced during Navy activities involving sonar and other transducers.

As noted in the *ANSI Sound Exposure Guideline* technical report (Popper et al., 2014), some fish species with a swim bladder that is involved in hearing may be more susceptible to TTS from high-intensity non-impulsive sound sources, such as sonar and other transducers, depending on the duration and frequency content of the exposure. Fishes with a swim bladder involved in hearing and fishes with high-frequency hearing may exhibit TTS from exposure to low- and mid-frequency sonar, specifically at cumulative sound exposure levels above 215 dB re 1 μPa^2-s. However, fishes without a swim bladder and fishes with a swim bladder that is not involved in hearing would be unlikely to detect mid- or other high-frequency sonars and would likely require a much higher sound exposure level to exhibit the same effect from exposure to low-frequency active sonar.

Hearing Loss due to Vessel Noise

Little data exist on the effects of vessel noise on hearing in fishes. However, TTS has been observed in fishes exposed to elevated background noise and other non-impulsive sources (e.g., white noise). Caged studies on pressure sensitive fishes (i.e., fishes with a swim bladder involved in hearing and those with high-frequency hearing) show some hearing loss after several days or weeks of exposure to increased background sounds, although the hearing loss seems to recover (e.g., Breitzler et al., 2020; Scholik & Yan, 2002a; Smith et al., 2006; Smith et al., 2004a). Smith et al. (2006; 2004a) exposed goldfish, to noise with a sound pressure level of 170 dB re 1 µPa and found a clear relationship between the amount of hearing loss and the duration of exposure until maximum hearing loss occurred at about 24 hours of exposure. A 10-minute exposure resulted in 5 dB of TTS, whereas a three-week exposure resulted in a 28 dB TTS that took over two weeks to return to pre-exposure levels (Smith et al., 2004a). Recovery times were not measured by investigators for shorter exposure durations. It is important to note that these exposures were continuous and subjects were unable to avoid the sound source for the duration of the experiment.

Scholik and Yan (2001) demonstrated TTS in fathead minnows (*Pimephales promelas*) after a 24-hour continuous exposure to white noise (0.3–2.0 kHz) at 142 dB re 1 µPa that took up to 14 days post-exposure to recover. This is the longest recorded time for a threshold shift to recover in a fish. The same authors also found that the bluegill sunfish (*Lepomis macrochirus*), a species that primarily detects particle motion and lacks specializations for hearing, did not show significant elevations in auditory thresholds when exposed to the same stimulus (Scholik & Yan, 2002b). This demonstrates again that fishes with a swim bladder involved in hearing and those with high-frequency hearing may be more sensitive to hearing loss than fishes without a swim bladder or those with a swim bladder not involved in hearing. Breitzler et al. (2020) exposed zebrafish (a freshwater species with a swim bladder involved in hearing) to 24 hours of white noise at various frequencies and sound levels. This is one of the first studies that measured hearing thresholds, physical damage (i.e., loss of hair cells) and recovery post-exposure. Overall, results were similar to those from previous studies. As the noise level increased, the amount of TTS observed in zebrafish also increased and frequencies that were most affected were those within the fishes best hearing sensitivity. Breitzler et al. (2020) also observed an increase in response latency in fish with TTS (i.e., the fish were slower to respond to auditory stimuli during hearing tests). Threshold shifts in fish exposed to sound pressure levels of 130 and 140 dB re 1 µPa recovered within three days whereas it took up to 14 days for fish exposed to the highest sound pressure level (150 dB re 1 µPa) to return to pre-exposure levels. Similarly, response latency was time dependent and sometimes took up to 14 days to recover to pre-exposure levels. The highest threshold shifts recorded also resulted in significant hair cell loss, whereas lower exposure levels did not. Similar to the other effects measured in this study, hair cell loss attributed to the highest exposure level returned to baseline levels within seven days post-exposure. This further demonstrates the ability for fish to rejuvenate hair cells and for hearing thresholds to recover to baseline levels (lacking evidence of PTS).

Butler et al. (2020) presented playbacks of pure tones ranging from 100 to 2,000 Hz to African cichlids (*Astatotilapia burtoni*), a freshwater species with a swim bladder involved in hearing, stationed in a small aquarium to investigate the effects on hearing. Playbacks were presented at a sound pressure level of 140 dB re 1 µPa for three hours. After review of the playback, the authors note that the sound source was more broadband than intended and therefore may not be analogous to other tonal sources (such as sonar) but rather and could more comparable to vessel noise playbacks or an example of elevated background levels. Observed threshold shifts were only significantly different than controls in lower frequencies (200 and 300 Hz) which corresponds to the species best range of sensitivity. Recovery of hearing thresholds was not measured during this study.

When reviewing results from the above studies, it is important to note that the fish were unable to avoid the sound source (e.g., held stationary in a tubs or tanks) and were subject to long, continuous duration exposures (e.g., days to weeks). A direct comparison of these results to fish exposed to continuous sound sources in natural settings should be treated with caution. For example, fishes that are exposed to noise produced by a vessel passing by in their natural environment, even in areas with high levels of vessel movement, would only be exposed for periods of short durations (e.g., seconds or minutes) and therefore relatively low sound exposure levels as vessels pass by. As evidence suggests that fish can recover from hearing loss (both threshold sensitivity and actual physical damage) even after long duration exposures in a confined space, it also indicates similar results to lower level and shorter duration exposures. Therefore, overall effects would not likely rise to the level of impact demonstrated in the summarized laboratory studies.

As noted in the *ANSI Sound Exposure Guideline* technical report (Popper et al., 2014), some fish species with a swim bladder that is involved in hearing may be more susceptible to TTS from long duration continuous noise, such as broadband[2] white noise, depending on the duration of the exposure (thresholds are proposed based on continuous exposure of 12 hours). However, it is not likely that TTS would occur in fishes with a swim bladder not involved in hearing or in fishes without a swim bladder.

[2] A sound or signal that contains energy across multiple frequencies.

3.9.3.1.1.3 Masking

Masking refers to the presence of a noise that interferes with a fish's ability to hear biologically important sounds including those produced by prey, predators, or other fishes. Masking occurs in all vertebrate groups and can result in a reduction in communication and listening space, effectively limiting the distance over which an animal can communicate and detect biologically relevant sounds (Pine et al., 2020). Human-generated continuous sounds (e.g., some sonar, vessel or aircraft noise, and vibratory pile driving) have the potential to mask sounds that are biologically important to fishes. Researchers have studied masking in fishes using continuous masking noise, but masking due to intermittent, short-duty cycle sounds has not been studied. Section 3.0.3.7 (Conceptual Framework for Assessing Effects from Acoustic and Explosive Activities) provides additional information on masking and the framework used to analyze this potential impact.

Masking is likely to occur in most fishes due to varying levels of ambient or natural noise in the environment such as wave action, precipitation, or other animal vocalizations (Popper et al., 2014). Ambient noise during higher sea states in the ocean has resulted in elevated thresholds in several fish species (Chapman & Hawkins, 1973; Ramcharitar & Popper, 2004). Although the overall intensity or loudness of ambient or human-generated noise may result in masking effects in fishes, masking may be most problematic when human-generated signals or ambient noise levels overlap the frequencies of biologically important signals (Buerkle, 1968, 1969; Popper et al., 2014; Tavolga, 1974).

Wysocki and Ladich (2005) investigated the influence of continuous white noise exposure on the auditory sensitivity of two freshwater fish with notable hearing specializations for sound pressure detection; the goldfish; the lined Raphael catfish (*Platydoras costatus*), a freshwater fish without notable specializations; and the pumpkinseed sunfish (*Lepomis gibbosus*). For the goldfish and catfish, baseline thresholds were lower than masked thresholds. Continuous white noise with a sound pressure level of approximately 130 dB re 1 µPa at 1 m resulted in an elevated threshold of 23 to 44 dB within the subjects' region of best sensitivity between 500 and 1,000 Hz. There was less evidence of masking in the sunfish during the same exposures with only a shift of 11 dB. Wysocki and Ladich (2005) suggest that ambient sound regimes may limit acoustic communication and orientation, especially in animals with notable hearing specializations for sound pressure detection.

Masking could lead to potential fitness costs depending on the severity of the reaction and the animals' ability to adapt or compensate during an exposure (de Jong et al., 2020; Radford et al., 2014; Slabbekoorn et al., 2010). For example, masking could result in changes in predator-prey relationships potentially inhibiting a fish's ability to detect predators and therefore increase its risk of predation (Astrup, 1999; Mann et al., 1998; Simpson et al., 2015; Simpson et al., 2016). Masking may also limit the distance over which fish can communicate or detect important signals (Alves et al., 2016; Codarin et al., 2009; Ramcharitar et al., 2006; Ramcharitar et al., 2001; Stanley et al., 2017), including vocalizations made during reproductive phases or sounds emitted from a reef for navigating larvae (de Jong et al., 2020; Higgs, 2005; Neenan et al., 2016). If the masking signal is brief (a few seconds or less), biologically important signals may still be detected, resulting in little effect to the individual. If the signal is longer in duration (minutes or hours) or overlaps with important frequencies for a particular species, more severe consequences may occur such as the inability to attract a mate and reproduce. Holt and Johnston (2014) were the first to demonstrate the Lombard effect in one species of fish, a potentially compensatory behavior where an animal increases the source level of its vocalizations in response to elevated noise levels. The Lombard effect is currently understood to be a reflex that may be unnoticeable to the animal, or it could lead to increased energy expenditure during communication.

The *ANSI Sound Exposure Guideline* technical report (Popper et al., 2014) highlights a lack of data that exists for masking by sonar but suggests that the narrow bandwidth and intermittent nature of most sonar signals would result in only a limited probability of any masking effects. In addition, most sonars (mid-, high-, and very high-frequency) are above the hearing range of most marine fish species, eliminating the possibility of masking for these species. In most cases, the probability of masking would further decrease with increasing distance from the sound source.

In addition, no data are available on masking by impulsive signals (e.g., impact pile driving and air guns) (Popper et al., 2014). Impulsive sounds are typically brief, lasting only fractions of a second, where masking could occur only during that brief duration of sound. Biological sounds can typically be detected between pulses within close distances to the source unless those biological sounds are similar to the masking noise, such as impulsive or drumming vocalizations made by some fishes (e.g., cod or haddock). Masking could also indirectly occur because of repetitive impulsive signals where the repetitive sounds and reverberations over distance may create a more continuous noise exposure.

Although there is evidence of masking as a result of exposure to vessel noise, the *ANSI Sound Exposure Guideline* technical report (Popper et al., 2014) does not present numeric thresholds for this effect. Instead, relative risk factors are considered and it is assumed the probability of masking occurring is higher at near to moderate distances from the source (up to hundreds of meters) but decrease with increasing distance (Popper et al., 2014).

3.9.3.1.1.4 Physiological Stress

Section 3.0.3.7 (Conceptual Framework for Assessing Effects from Acoustic and Explosive Activities) provides additional information on physiological stress and the framework used to analyze this potential impact. A fish must first be able to detect a sound above its hearing threshold and above the ambient noise level before a physiological stress reaction can occur. The initial response to a stimulus is a rapid release of stress hormones into the circulatory system, which may cause other responses such as elevated heart rate and blood chemistry changes. Increases in background sound have been shown to cause stress in humans and animals, which also includes the measurement of biochemical responses by fishes to acoustic stress (e.g., Goetz et al., 2015; Madaro et al., 2015; Remage-Healey et al., 2006; Smith et al., 2004b; Wysocki et al., 2007; Wysocki et al., 2006). However, results from these studies have varied. Stimuli that have been used to study physiological stress responses in fishes include predator vocalizations, non-impulsive or continuous, and impulsive noise exposures.

A stress response that has been observed in fishes includes the production of cortisol (a stress hormone) when exposed to sounds such as boat noise, tones, or predator vocalizations. Nichols et al. (2015) found that giant kelpfish (*Heterostichus rostratus*) had increased levels of cortisol with increased sound level and intermittency of boat noise playbacks. Cod exposed to a short-duration upsweep (a tone that sweeps upward across multiple frequencies) across 100 to 1,000 Hz had increases in cortisol levels, which returned to normal within one hour post-exposure (Sierra-Flores et al., 2015). Remage-Healey et al. (2006) found elevated cortisol levels in Gulf toadfish (*Opsanus beta*) exposed to low-frequency bottlenose dolphin sounds, but observed no physiological change when they exposed toadfish to low-frequency “pops” produced by snapping shrimp.

A sudden increase in sound pressure level (i.e., presentation of a sound source) or an increase in overall background noise levels can increase hormone levels and alter other metabolic rates indicative of a stress response, such as increased ventilation and oxygen consumption (Pickering, 1981; Popper & Hastings, 2009a; Radford et al., 2016; Simpson et al., 2015; Simpson et al., 2016; Smith et al., 2004a, 2004b; Spiga et al., 2017). Similarly, reef fish embryos exposed to boat noise have demonstrated changes in morphological development and increases in heart rate, another indication of a physiological stress response, although survival rates were unchanged (Fakan & McCormick, 2019; Jain-Schlaepfer et al., 2018). Although results have varied, it has been shown that chronic or long-term (days or weeks) exposures of continuous man-made sounds can lead to a reduction in embryo viability (Sierra-Flores et al., 2015) and decreased growth rates (Nedelec et al., 2015).

Mills et al. (2020) observed the hormonal effects of motorboat noise on orange-fin anemonefish (*Amphiprion chrysopterus*) over short-term (30 minute) and longer-term (48 hour) periods. Cortisol levels did not differ significantly between the periods for either sex. Testosterone levels were significantly higher in males exposed to motorboat-noise playback and 11-ketotestosterone (11-KT) levels were significantly higher in males during the short-term experiment and in both sexes during the longer-term experiment.

Kusku (2020) measured respiratory changes as secondary indicators of stress in Nile tilapia (*Oreochromis niloticus*) to determine potential effects of long-term exposure to underwater sound playback, including shipping noise. Fish exposed to noise showed as much as a two-fold increase in respiratory indicators (opercular beat rate and pectoral wing rate) after 10 minutes of sound exposure as compared to controls and pre-exposure rates. Over the next 120 days of continuous sound exposure, respiratory indicators declined steadily and returned to baseline. The authors conclude that the data support habituation of fish to chronic noise exposure.

However, not all species show these reactions. Smith et al. (2004b) found no increase in corticosteroid, a class of stress hormones, in goldfish exposed to a continuous, band-limited noise (0.1–10 kHz) with a sound pressure level of 170 dB re 1 µPa for one month. Wysocki et al. (2007) exposed rainbow trout to continuous band-limited noise with a sound pressure level of about 150 dB re 1 µPa for nine months with no observed stress effects. Growth rates and effects on the trout's immune systems were not significantly different from control animals held at a sound pressure level of 110 dB re 1 µPa. In addition, although there was a difference of 10 dB in overall background level and boat activity between test sites, reef fish, *Halichoeres bivittatus,* showed similar levels of whole-body cortisol (Staaterman et al., 2020). This suggests that boat noise, in this context, was not as stressful as handling of the fish for this particular experiment and contradicts previous conclusions that follow similar study designs.

Fishes may have physiological stress reactions to sounds that they can hear. Generally, stress responses are more likely to occur in the presence of potentially threatening sound sources, such as predator vocalizations, or the sudden onset of impulsive signals rather than from non-impulsive or continuous sources such as vessel noise or sonar. If an exposure is short, the stress responses are typically brief (a few seconds to minutes). In addition, research shows that fishes may habituate (i.e., learn to tolerate) to the noise that is being presented after multiple exposures or longer duration exposures that prove to be non-threatening. However, exposure to chronic noise sources can lead to more severe impacts over time, such as reduced growth rates which can lead to reduced survivability for an individual. It is assumed that any physiological response (e.g., hearing loss or injury) or significant behavioral response is also associated with a stress response.

3.9.3.1.1.5 Behavioral Reactions

Section 3.0.3.7 (Conceptual Framework for Assessing Effects from Acoustic and Explosive Activities) provides additional information on behavioral reactions and the framework used to analyze this potential impact. Behavioral reactions in fishes have been observed due to a number of different types of sound sources. The majority of research has been performed using air guns (including large-scale seismic surveys), sonar, and vessel noise. Fewer observations have been made on behavioral reactions to impact pile driving noise; although fish are likely to show similar behavioral reactions to any impulsive noise within or outside the zone for hearing loss and injury.

As with masking, a fish must first be able to detect a sound above its hearing threshold and above the ambient noise level before a behavioral reaction can occur. Most fishes can only detect low-frequency sounds with the exception of a few species that can detect some mid and high frequencies (above 1 kHz).

Fish studies have identified the following behavioral reactions to sound: alteration of natural behaviors (e.g., startle or alarm), and avoidance (LGL Ltd Environmental Research Associates et al., 2008; McCauley et al., 2000; Pearson et al., 1992). In the context of this Supplemental, and to remain consistent with available behavioral reaction literature, the terms “startle,” “alarm,” “response,” and “reaction” will be used synonymously.

In addition, observed behavioral effects to fish could include disruption to or alteration of natural activities such as swimming, schooling, feeding, breeding, and migrating. Sudden changes in sound level can cause fish to dive, rise, or change swimming direction. However, some fish either do not respond, learn to tolerate or habituate to repeated exposures, or learn to tolerate noise that seems threatening (e.g., Bruintjes et al., 2016; Currie et al., 2020; Hubert et al., 2020; Nedelec et al., 2016b; Radford et al., 2016). Research on behavioral reactions can be difficult to understand and interpret. For example, behavioral responses often times vary depending on the type of exposure and sound source present. Changes in sound intensity may be more important to a fish’s behavior than the maximum sound level. Some studies show that sounds that fluctuate in level or have intermittent pulse rates tend to elicit stronger responses from fish than even stronger sounds with a continuous level (Currie et al., 2020; Neo et al., 2014; Schwarz & Greer, 1984). It has also been suggested that unpredictable sounds that last for long durations may have the largest impact on behavioral responses (de Jong et al., 2020). Interpreting behavioral responses can also be difficult due to species-specific behavioral tendencies, motivational state (e.g., feeding or mating), an individual’s previous experience, how resilient a species is to changes in their environment, and whether or not the fish are able to avoid the source (e.g., caged versus free-swimming subjects). Results from caged studies may not provide a clear understanding of how free-swimming fishes may react to the same or similar sound exposures (Hawkins et al., 2015).

Behavioral Reactions due to Impulsive Sound Sources

It is assumed that most species would react similarly to impulsive sources such as weapons noise and explosions. However, it is important to note that most data on behavioral reactions to impulsive sources is collected from studies using air guns and impact pile driving, sources that do not occur in the Study Area. Reactions include startle or alarm responses and increased swim speeds at the onset of impulsive sounds (Fewtrell & McCauley, 2012; Pearson et al., 1992; Roberts et al., 2016a; Spiga et al., 2017). Data on fish behavioral reactions exposed to impulsive sound sources is mostly limited to studies using caged fishes and seismic air guns (Løkkeborg et al., 2012). Several species of rockfish (*Sebastes* species) in a caged environment exhibited startle or alarm reactions to seismic air gun pulses between peak-to-peak sound pressure levels of 180 dB re 1 µPa and 205 dB re 1 µPa (Pearson et al., 1992). More subtle behavioral changes were noted at lower sound pressure levels, including decreased swim speeds. At the presentation of the sound, some species of rockfish settled to the bottom of the experimental enclosure and reduced swim speed. Trevally (*Pseudocaranx dentex*) and pink snapper (*Pagrus auratus*) also exhibited alert responses as well as changes in swim depth, speed, and schooling behaviors when exposed to air gun noise (Fewtrell & McCauley, 2012). Both trevally and pink snapper swam faster and closer to the bottom of the cage at the onset of the exposure. However, trevally swam in tightly cohesive groups at the bottom of the test cages while pink snapper exhibited much looser group cohesion. These behavioral responses were seen during sound exposure levels as low as 147 up to 161 dB re 1 µPa^2-s but habituation occurred in all cases, either within a few minutes or within 30 minutes after the final air gun shot (Fewtrell & McCauley, 2012; Pearson et al., 1992).

Some studies have shown a lack of behavioral reactions to air gun noise. Herring exposed to an approaching air gun survey (from 27 to 2 km over six hours), resulting in single pulse sound exposure levels of 125 to 155 dB re 1 µPa^2-s, did not react by changing direction or swim speed (Pena et al., 2013). Although these levels are similar to those tested in other studies which exhibited responses (Fewtrell & McCauley, 2012), the distance of the exposure to the test enclosure, the slow onset of the sound source, and a strong motivation for feeding may have affected the observed response (Pena et al., 2013). In another study, Wardle et al. (2001) observed marine fish on an inshore reef before, during, and after an air gun survey at varying distances. The air guns were calibrated at a peak level of 210 dB re 1 µPa at 16 m and 195 dB re 1 µPa at 109 m from the source. Other than observed startle responses and small changes in the position of pollack, when the air gun was located within close proximity to the test site (within 10 m), they found no substantial or permanent changes in the behavior of the fish on the reef throughout the course of the study. Behavioral responses to impulsive sources are more likely to occur within near and intermediate (tens to hundreds of meters) distances from the source as opposed to far distances (thousands of meters) (Popper et al., 2014).

Unlike the previous studies, Slotte et al. (2004) used fishing sonar (38 kHz echo sounder) to monitor behavior and depth of blue whiting (*Micromesistius poutassou*) and Norwegian spring herring (*Clupea harengus L.*) spawning schools exposed to air gun signals. They reported that fishes in the area of the air guns appeared to go to greater depths after the air gun exposure compared to their vertical position prior to the air gun usage. Moreover, the abundance of animals 30–50 km away from the air guns increased during seismic activity, suggesting that migrating fish left the zone of seismic activity and did not re-enter the area until the activity ceased. It is unlikely that either species was able to detect the fishing sonar. However, it should be noted that these behavior patterns may have also been influenced by other variables such as motivation for feeding, migration, or other environmental factors (e.g., temperature, salinity, etc.) (Slotte et al., 2004).

Bruce et al. (2018) attached acoustic and accelerometer tags to swell sharks (*Cephaloscyllium laticeps)*, gummy sharks (*Mustelus antarcticus)*, and tiger flathead (*Neoplatycephalus richardsoni*) in order to monitor their behavior during seismic surveys. Although tagging was successful and provided a large sample size for two out of the three species, most tagged individuals moved out of range of the experimental site where autonomous acoustic receivers were placed or sporadically returned to the monitoring site throughout the duration of the survey. This made it difficult to correlate displacement from the area with the actual survey. In addition to the analysis of fish behavior, modeled predicted catch rates within the experimental site were compared to actual catch per unit effort data collected from local fisheries. Of the nine species analyzed, only three of them showed reductions in catch rates following the seismic survey. Contrary to past findings and assumptions, catch rates for six species actually increased after the survey. Although these findings are interesting and, in some ways, may contradict prior conclusions, there are some improvements that should be made to similar studies in the future to better understand the true effects of seismic surveys on fish behavior and catch rates.

Alterations in natural behavior patterns due to exposure to pile driving noise have not been studied as thoroughly, but reactions noted thus far are similar to those seen in response to seismic surveys. These changes in behavior include startle responses, changes in depth (in both caged and free-swimming subjects), increased swim speeds, changes in ventilation rates, changes in attention and anti-predator behaviors, and directional avoidance (e.g., Hawkins et al., 2014; Mueller-Blenkle et al., 2010; Neo et al., 2015; Roberts et al., 2016a; Spiga et al., 2017). The severity of response varied greatly by species and received sound pressure level of the exposure. For example, some minor behavioral reactions such as startle responses were observed during caged studies with a sound pressure level as low as 140 dB re 1 μPa (Neo et al., 2014). However, only some free-swimming fishes avoided pile driving noise at even higher sound pressure levels between 152 and 157 dB re 1 μPa (Iafrate et al., 2016). In addition, Roberts et al. (2016a) observed that although multiple species of free swimming fish responded to simulated pile driving recordings, not all responded consistently. In some cases, only one fish would respond while the others continued feeding from a baited remote underwater video. In other instances, various individual fish would respond to different strikes. The repetition rate of pulses during an exposure may also have an effect on what behaviors were noted and how quickly these behaviors recovered as opposed to the overall sound pressure or exposure level (Neo et al., 2014). Neo et al. (2014) observed slower recovery times in fishes exposed to intermittent sounds (similar to pile driving) compared to continuous exposures.

As summarized in the *ANSI Sound Exposure Guideline* technical report (Popper et al., 2014), species may react differently to the same sound source depending on a number of variables, such as the animal's life stage or behavioral state (e.g., feeding, mating). Without specific data, it is assumed that fishes react similarly to all impulsive sounds outside the zone for hearing loss and injury. Observations of fish reactions to large-scale air gun surveys are informative, but not necessarily directly applicable to analyzing impacts from the short-term, intermittent use of all impulsive sources. It is assumed that fish have a high probability of reacting to an impulsive sound source within near and intermediate distances (tens to hundreds of meters), and a decreasing probability of reaction at increasing distances (Popper et al., 2014).

Behavioral Reactions due to Sonar and Other Transducers

Behavioral reactions to sonar have been studied both in caged and free-swimming fish, although results can often-times be difficult to interpret depending on the species tested and the study environment. Jørgensen et al. (2005) showed that caged cod and spotted wolf fish (*Anarhichas minor*) lacked any response to simulated sonar between 1 and 8 kHz. However, within the same study, reactions were seen in juvenile herring. It is likely that the sonar signals were inaudible to the cod and wolf fish (species that lack notable hearing specializations), but audible to herring (a species that has hearing capabilities in the frequency ranges tested).

Doksæter et al. (2009; 2012) and Sivle et al. (2014; 2012) studied the reactions of both wild and captive Atlantic herring to the Royal Netherlands Navy's experimental mid-frequency active sonar ranging from 1 to 7 kHz. The behavior of the fish was monitored in each study either using upward looking echosounders (for wild herring) or audio and video monitoring systems (for captive herring). The source levels used within each study varied across all studies and exposures with a maximum received sound pressure level of 181 dB re 1 μPa and maximum cumulative sound exposure level of 184 dB re 1 $\mu Pa^2 \cdot s$. No avoidance or escape reactions were observed when herring were exposed to any sonar sources. Instead, significant reactions were noted at lower received sound levels of different non-sonar sound types. For example, dive responses (i.e., escape reactions) were observed when herring were exposed to killer whale feeding sounds at received sound pressure levels of approximately 150 dB re 1 µPa (Sivle et al., 2012). Startle responses were seen when the cages for captive herring were hit with a wooden stick and with the ignition of an outboard boat engine at a distance of one meter from the test pen (Doksaeter et al., 2012). It is possible that the herring were not disturbed by the sonar, were more motivated to continue other behaviors such as feeding, or did not associate the sound as a threatening stimulus. Based on these results (Doksaeter et al., 2009; Doksaeter et al., 2012; Sivle et al., 2012), Sivle et al. (2014) created a model in order to report on the possible population-level effects on Atlantic herring from active naval sonar. The authors concluded that the use of naval sonar poses little risk to populations of herring regardless of season, even when the herring populations are aggregated and directly exposed to sonar.

There is evidence that elasmobranchs (cartilaginous fish including sharks and rays) also respond to human-generated sounds. A number of researchers conducted experiments in which they played back sounds (e.g., pulsed tones below 1 kHz) and attracted a number of different shark species to the sound source (e.g., Casper et al., 2012a; Myrberg et al., 1976; Myrberg et al., 1969; Myrberg et al., 1972; Nelson & Johnson, 1972). The results of these studies showed that sharks were attracted to irregularly pulsed low-frequency sounds (below several hundred Hz), in the same frequency range of sounds that might be produced by struggling prey. However, abrupt and irregularly pulsed human-generated noise (0.2-10 kHz, with most energy below 1 kHz) resulted in withdrawal responses of certain shark species (Chapuis et al., 2019). Sharks are not known to be attracted to continuous signals or higher frequencies that they presumably cannot hear (Casper & Mann, 2006; Casper & Mann, 2009).

Only a few species of marine fishes can detect sonars above 1 kHz (see Section 3.9.2.1, Hearing and Vocalization), meaning that most fishes would not detect most mid-, high-, or very high-frequency Navy sonars. The few marine species that can detect above 1 kHz and have some hearing specializations may be able to better detect the sound and would therefore be more likely to react. However, researchers have found little reaction by adult fish in the wild to sonars within the animals' hearing range (Doksaeter et al., 2009; Doksaeter et al., 2012; Sivle et al., 2012). The *ANSI Sound Exposure Guideline* technical report (Popper et al., 2014) suggests that fish able to hear sonars would have a low probability of reacting to the source within near or intermediate distances (within tens to hundreds of meters) and a decreasing probability of reacting at increasing distances.

<u>Behavioral Reactions due to Vessel Noise</u>

Vessel traffic also contributes to the amount of noise in the ocean and has the potential to affect fishes. Several studies have demonstrated and reviewed avoidance responses by fishes (e.g., herring and cod) to the low-frequency sounds of vessels (De Robertis & Handegard, 2013; Engås et al., 1995; Handegard et al., 2003). Misund (1997) found fish ahead of a ship that showed avoidance reactions did so at ranges of 50 to 150 m. When the vessel passed over them, some species of fish responded with sudden escape responses that included lateral avoidance or downward compression of the school.

As mentioned above, behavioral reactions are quite variable depending on a number of factors such as (but not limited to) the type of fish, its life history stage, behavior, time of day, location, the sound source (e.g., type of vessel or motor vs. playback of broadband sounds), and the sound propagation characteristics of the water column (Popper et al., 2014; Schwarz & Greer, 1984). Reactions to playbacks of continuous noise or passing vessels generally include basic startle and avoidance responses, as well as evidence of distraction and increased decision-making errors. Other observed responses include increased group cohesion; increased distractions or evidence of modified attention; changes in vertical distribution in the water column, swim speeds, distance traveled, and feeding efficacy such as reduced foraging attempts and increased mistakes (i.e., lowered discrimination between food and non-food items) (e.g., Bracciali et al., 2012; De Robertis & Handegard, 2013; Handegard et al., 2015; McCormick et al., 2019; Nedelec et al., 2017a; Nedelec et al., 2015; Neo et al., 2015; Payne et al., 2015; Purser & Radford, 2011; Roberts et al., 2016a; Sabet et al., 2016; Simpson et al., 2015; Simpson et al., 2016; Voellmy et al., 2014a; Voellmy et al., 2014b). In addition, Butler et al. (2020) observed changes in aggressive and reproductive behaviors in African cichlids exposed to broadband playbacks in a small aquarium such as changes in visual displays and signaling to potential mates and competitors, alterations in territorial interactions, and a decrease in successful courtship behaviors. Mills et al. (2020) observed the behavioral effects of motorboat noise on orange-fin anemonefish (*Amphiprion chrysopterus*) over short-term (30 minute) and longer-term (48 hour) periods. Significant behavioral effects included increased hiding, reduction in distance from anemone, and increased aggressive behavior toward heterospecifics over both time periods.

Behavioral responses may also be dependent on the type of vessel exposed to a fish. For example, juvenile damselfish (*Pomacentrus wardi*) exposed to sound from a two-stroke engine resulted in startle responses, reduction in boldness (increased time spent hiding, less time exhibiting exploratory behaviors) and space use (maximum distance ventured from shelter or traveled within the test enclosure), as well as slower and more conservative reactions to visual stimuli analogous to a potential predator. However, damselfish exposed to sound from a four-stroke engine generally displayed similar responses as control fish exposed to ambient noise (e.g., little or no change in boldness) (McCormick et al., 2018; McCormick et al., 2019). Although the two sound sources were very similar, the vessels powered by the four-stroke engine were of lower intensity compared to vessels powered by the two-stroke engine, which may explain the overall reduced response to this engine type.

Vessel noise has also led to changes in anti-predator response, but these responses vary by species. During exposures to vessel noise, juvenile Ambon damselfish (*Pomacentrus amboinensis*) and European eels showed slower reaction times and lacked startle responses to predatory attacks, and subsequently showed signs of distraction and increased their risk of predation during both simulated and actual predation experiments (Simpson et al., 2015; Simpson et al., 2016). Furthermore, juvenile Ambon damselfish showed a reduction in learned anti-predator behaviors, likely as a result of distraction, which could lead to an increased risk to survival (Ferrari et al., 2018). Spiny chromis (*Acanthochromis polyacanthus*) exposed to chronic boat noise playbacks for up to 12 consecutive days spent less time feeding and interacting with offspring, and displayed increased defensive acts. In addition, offspring survival rates were also lower at nests exposed to chronic boat noise playbacks versus those exposed to ambient playbacks (Nedelec et al., 2017b). This suggests that chronic or long-term exposures could have more severe consequences than brief exposures.

In contrast, larval Atlantic cod showed a stronger anti-predator response and were more difficult to capture during simulated predator attacks (Nedelec et al., 2015). There are also observations of a general lack of response to shipping and pile driving playback noise by grey mullet (*Chelon labrosus*) and the two spotted goby (*Gobiusculus flavescens*) (Roberts et al., 2016b), as well as no effect of boat noise or presence on round goby (*Neogobius melanostomus*) calling behaviors (Higgs & Humphrey, 2019). Mensinger et al. (2018) found that Australian snapper (*Pagrus auratus*) located in a protected area showed no change in feeding behavior or avoidance during boat passes, whereas snapper in areas where fishing occurs startled and ceased feeding behaviors during boat presence. This supports that location and past experience also have an influence on whether fishes react.

Although behavioral responses such as those listed above were often noted during the onset of most sound presentations, most behaviors did not last long and animals quickly returned to baseline behavior patterns. In fact, in one study, when given the chance to move from a noisy tank (with sound pressure levels reaching 120–140 dB re 1 µPa) to a quieter tank (sound pressure levels of 110 dB re 1 µPa), there was no evidence of avoidance. The fish did not seem to prefer the quieter environment and continued to swim between the two tanks comparable to control sessions (Neo et al., 2015). However, many of these reactions are difficult to extrapolate to real-world conditions due to the captive environment in which testing occurred.

To investigate potential avoidance on a larger scale, Ivanova et al. (2020) tagged Arctic cod and recorded movement and behavior during exposure to noise produced by cargo and cruise ship traffic. Overall, cod increased their horizontal movement outside of their estimated home range when vessels were either present or moving, compared to periods where vessels were absent, indicating periods of potential avoidance. In addition, changes in feeding, travel, and search behaviors were observed when comparing each sound condition. Future studies should continue to investigate whether these observed effects are prolonged or how quickly fish may return to their home range and baseline behaviors.

Most fish species should be able to detect vessel noise due to its low-frequency content and their hearing capabilities (see Section 3.9.2.1, Hearing and Vocalization). The *ANSI Sound Exposure Guideline* technical report (Popper et al., 2014) suggests that fishes have a high to moderate probability of reacting to nearby vessel noise (i.e., within tens of meters) with decreasing probability of reactions with increasing distance from the source (hundreds or more meters).

3.9.3.1.1.6 Long-Term Consequences

Section 3.0.3.7 (Conceptual Framework for Assessing Effects from Acoustic and Explosive Activities) provides additional information on potential pathways for long-term consequences. Mortality removes an individual fish from the population and injury reduces the fitness of an individual. Few studies have been conducted on any long-term consequences from repeated hearing loss, stress, or behavioral reactions in fishes due to exposure to loud sounds (Hawkins et al., 2015; Popper & Hastings, 2009a; Popper et al., 2014). Repeated exposures of an individual to multiple sound-producing activities over a season, year, or life stage could cause reactions with costs that can accumulate over time to cause long-term consequences for the individual. These long-term consequences may affect the survivability of the individual, or if impacting enough individuals may have population-level effects, including alteration from migration paths, avoidance of important habitat, or even cessation of foraging or reproductive behavior (Hawkins et al., 2015). Conversely, some animals habituate to or become tolerant of repeated exposures over time, learning to ignore a stimulus that in the past has not accompanied any overt threat. In fact, Sivle et al. (2016) predicted that exposures to sonar at the maximum levels tested would only result in short-term disturbance and would not likely affect the overall population in sensitive fishes such as Atlantic herring.

3.9.3.1.2 Impacts from Sonar and Other Transducers

The overall use of sonar and other transducers for training and testing would be similar to what was analyzed in the 2015 NWTT Final EIS/OEIS for some activities and would increase for other activities (see Tables 2.5-1, 2.5-2, and 3.0-2 for details). Although individual activities may vary some from those previously analyzed, and some new systems using new technologies will be tested under Alternative 1 and 2, the overall determinations presented in the 2015 NWTT Final EIS/OEIS remain valid.

Sonar and other transducers proposed for use are transient in most locations because activities that involve sonar and other transducers take place at different locations and many platforms are generally moving throughout the Study Area. A few activities involving sonar and other transducers occur in inshore waters (within bays and estuaries), including at pierside locations. Sonar and other transducers emit sound waves into the water to detect objects, safely navigate, and communicate. General categories and characteristics of these systems and the number of hours these sonars will be operated are described in Section 3.0.3.1.1 (Sonar and Other Transducers). The activities that use sonar and other transducers are described in Appendix A (Navy Activities Descriptions).

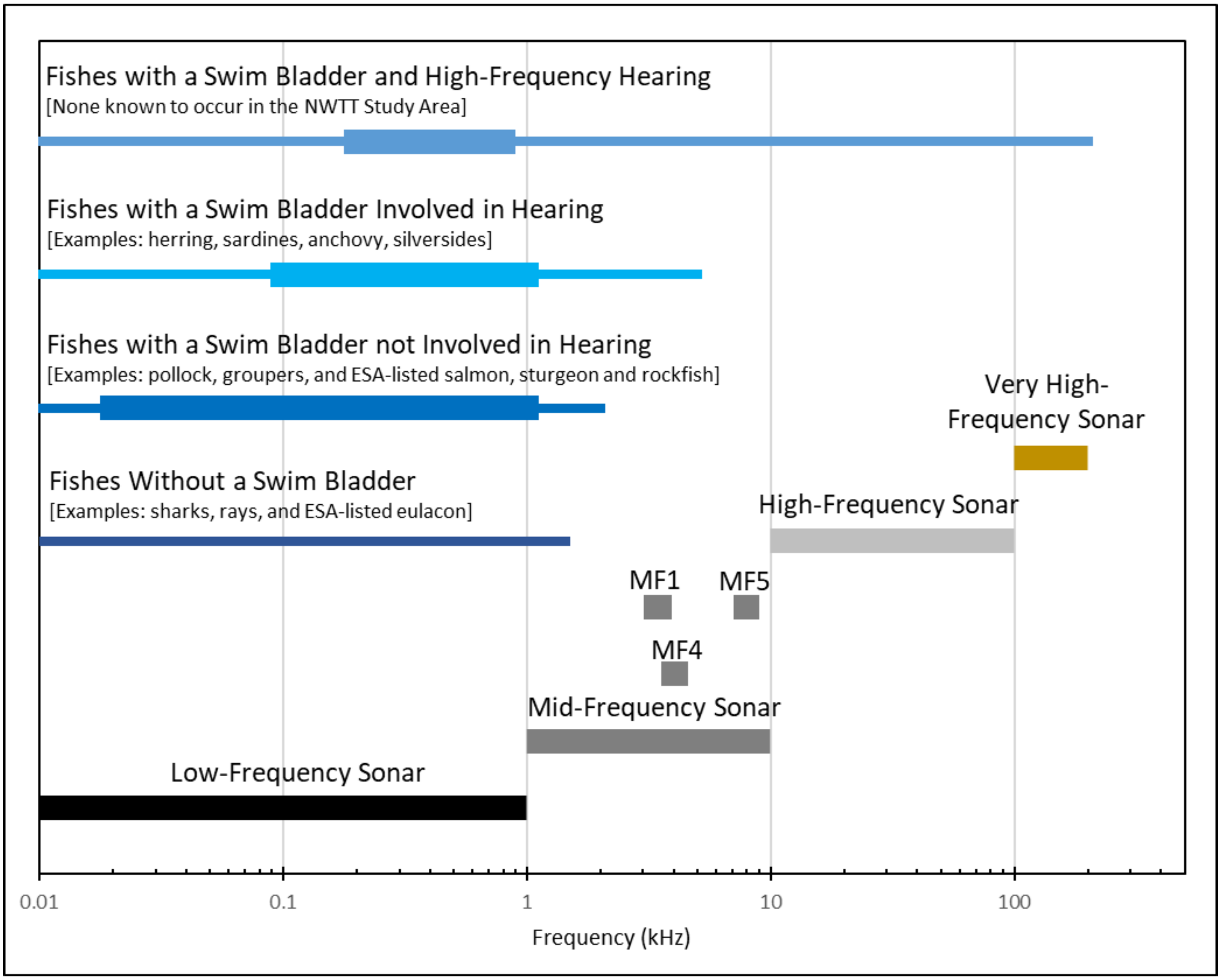
As described under Section 3.9.3.1.1.1 (Injury – Injury due to Sonar and Other Transducers), direct injury from sonar and other transducers is highly unlikely because injury has not been documented in fish exposed to sonar (Halvorsen et al., 2013; Halvorsen et al., 2012c; Popper et al., 2007) and therefore is not considered further in this analysis.

Fishes are not equally sensitive to noise at all frequencies. Fishes must first be able to hear a sound in order to be affected by it. As discussed in Section 3.9.2.1 (Hearing and Vocalization), many marine fish species tested to date hear primarily below 1 kHz. For the purposes of this analysis, fish species were grouped into one of four fish hearing groups based on either their known hearing ranges (i.e., audiograms) or physiological features that may be linked to overall hearing capabilities (i.e., swim bladder with connection to, or in close proximity to, the inner ear). Figure 3.9-6 provides a general summary of hearing threshold data from available literature (e.g., Casper & Mann, 2006; Deng et al., 2013; Kéver et al., 2014; Mann et al., 2001; Ramcharitar et al., 2006) to demonstrate the potential overall range of frequency detection for each hearing group.

Due to data limitations, these estimated hearing ranges may be overly conservative in that they may extend beyond what some species within a given fish hearing group may actually detect. For example, although most sharks are most sensitive to lower frequencies, well below 1 kHz, the bull shark has been tested and can detect frequencies up to 1.5 kHz (Kritzler & Wood, 1961; Myrberg, 2001) and therefore represents the uppermost known limit of frequency detection for this hearing group. These upper bounds of each fish hearing groups' frequency range are outside of the range of best sensitivity for the majority of fishes within that group. As a result, fishes within each group would only be able to detect those upper frequencies at close distances to the source, and from sources with relatively high source levels.

Figure 3.9-6 is not a composite audiogram but rather displays the basic overlap in potential frequency content for each hearing group with Navy defined sonar classes (i.e., low-, mid-, high- and very high-frequency) as discussed under Section 3.0.3.1.1 (Sonar and Other Transducers – Classification of Sonar and Other Transducers).

Systems within the low-frequency sonar class present the greatest potential for overlap with fish hearing. Some mid-frequency sonars and other transducers may also overlap some species' hearing ranges, but to a lesser extent than low-frequency sonars. For example, the only hearing groups that have the potential to detect mid-frequency sources within bins MF1, MF4 and MF5 are fishes with a swim bladder involved in hearing and with high-frequency hearing. It is anticipated that most marine fishes would not hear, or be affected by, mid-frequency Navy sonars or other transducers with operating frequencies greater than about 1–4 kHz. Only a few fish species (i.e., fish with a swim bladder and high-frequency hearing specializations) can detect, and therefore be potentially affected by, high- and very high-frequency sonars and other transducers.



Notes: Thin blue lines represent the estimated minimum and maximum range of frequency detection for the hearing group. All hearing groups are assumed to hear down to 0.01 kHz regardless of available data. Thicker portions of each blue line represent the estimated minimum and maximum range of best sensitivity for that group. Currently, no data are available to estimate the range of best sensitivity for fishes without a swim bladder. Although each sonar class is represented graphically by the horizontal black, grey and brown bars, not all sources within each class would operate at all the displayed frequencies. Example mid-frequency classes are provided to further demonstrate this. kHz = kilohertz, MF1 = 3.5 kHz, MF4 = 4 kHz, MF5 = 8 kHz.

Figure 3.9-6: Fish Hearing Group and Navy Sonar Bin Frequency Ranges

The most probable impacts from exposure to sonar and other transducers are TTS (for more detail see Section 3.9.3.1.1.2, Hearing Loss), masking (for more detail see Section 3.9.3.1.1.3, Masking), physiological stress (for more detail see Section 3.9.3.1.1.4, Physiological Stress), and behavioral reactions (for more detail see Section 3.9.3.1.1.5, Behavioral Reactions). Analysis of these effects are provided below.

3.9.3.1.2.1 Methods for Analyzing Impacts from Sonar and Other Transducers

The Navy performed a quantitative analysis to estimate the range to TTS for fishes exposed to sonar and other transducers used during Navy training and testing activities. Inputs to the quantitative analysis included sound propagation modeling in the Navy Acoustic Effects Model to the sound exposure criteria and thresholds presented below to predict ranges to effects. Although ranges to effect are predicted, density data for fish species within the Study Area are not available; therefore, it is not possible to estimate the total number of individuals that may be affected by sound produced by sonar and other transducers.

Criteria and thresholds to estimate impacts from sonar and other transducers are presented below in Table 3.9-3. Thresholds for hearing loss are typically reported in cumulative sound exposure level so as to account for the duration of the exposure. Therefore, thresholds reported in the *ANSI Sound Exposure Guideline* technical report (Popper et al., 2014) that were presented in other metrics were converted to sound exposure level based on the signal duration reported in the original studies (see Halvorsen et al., 2013; Halvorsen et al., 2012c; Kane et al., 2010; Popper et al., 2007). General research findings from these studies can be reviewed in Section 3.9.3.1.1.2 (Hearing Loss).

Table 3.9-3: Sound Exposure Criteria for TTS from Sonar

Fish Hearing Group	TTS from Low-Frequency Sonar (SEL_{cum})	TTS from Mid-Frequency Sonar (SEL_{cum})
Fishes without a swim bladder	NC	NC
Fishes with a swim bladder not involved in hearing	> 210	NC
Fishes with a swim bladder involved in hearing	210	220
Fishes with a swim bladder and high-frequency hearing	210	220

Notes: TTS = Temporary Threshold Shift, SEL_{cum} = Cumulative sound exposure level (decibel referenced to 1 micropascal squared seconds [dB re 1 μPa^2-s]), NC = effects from exposure to sonar is considered to be unlikely, therefore no criteria are reported, > indicates that the given effect would occur above the reported threshold.

For mid-frequency sonars, fishes with a swim bladder involved in hearing have shown signs of hearing loss because of mid-frequency sonar exposure at a maximum received sound pressure level of 210 dB re 1 µPa for a total duration of 15 seconds. To account for the total duration of the exposure, the threshold for TTS is a cumulative sound exposure level of 220 dB re 1 μPa^2-s (Halvorsen et al., 2012c; Kane et al., 2010). The same threshold is used for fishes with a swim bladder and high frequency hearing as a conservative measure although fishes in this hearing group have not been tested for the same impact. TTS has not been observed in fishes with a swim bladder that is not involved in hearing exposed to mid-frequency sonar. Fishes within this hearing group do not sense pressure well and typically cannot hear at frequencies above 1 kHz (Halvorsen et al., 2012c; Popper et al., 2014). Therefore, no criteria were proposed for fishes with a swim bladder that is not involved in hearing from exposure to mid-frequency sonars as it is considered unlikely for TTS to occur. Fishes without a swim bladder are even less susceptible to noise exposure; therefore, TTS is unlikely to occur, and no criteria are proposed for this group either.

For low-frequency sonar, as described in Section 3.9.3.1.1.2 (Hearing Loss), exposure of fishes with a swim bladder has resulted in TTS (Halvorsen et al., 2013; Kane et al., 2010; Popper et al., 2007). Specifically, fishes with a swim bladder not involved in hearing showed signs of hearing loss after exposure to a maximum received sound pressure level of 193 dB re 1 µPa for 324 and 648 seconds (cumulative sound exposure level of 218 and 220 dB re 1 µPa^2-s, respectively) (Kane et al., 2010; Popper et al., 2007). In addition, exposure of fishes with a swim bladder involved in hearing to low-frequency sonar at a sound pressure level of 195 dB re 1 µPa for 324 seconds (cumulative sound exposure level of 215 dB re 1 µPa^2-s) resulted in TTS (Halvorsen et al., 2013). Although the results were variable, it can be assumed that TTS may occur in fishes within the same hearing groups at similar exposure levels. As a conservative measure, the threshold for TTS from exposure to low-frequency sonar for all fish hearing groups with a swim bladder was rounded down to a cumulative sound exposure level of 210 dB re 1 µPa^2-s.

Criteria for high- and very-high-frequency sonar were not available in the *ANSI Sound Exposure Guideline* technical report (Popper et al., 2014); however, only species with a swim bladder involved in hearing and with high-frequency specializations, such as shad, could potentially be affected. The majority of fish species within the Study Area are unlikely to be able to detect these sounds. There is little data available on hearing loss from exposure of fishes to these high-frequency sonars. Due to the lack of available data, and as a conservative measure, effects to these hearing groups from high-frequency sonars would utilize the lowest threshold available for other hearing groups (a cumulative sound exposure level of 210 dB re 1 µPa^2-s), but effects would largely be analyzed qualitatively.

3.9.3.1.2.2 Impact Ranges for Sonar and Other Transducers

The following section provides ranges to specific effects from sonar and other transducers. Ranges are calculated using criteria from Table 3.9-4 and the Navy Acoustic Effects Model. Only ranges to TTS were predicted based on available data. Sonar durations of 1, 30, 60 and 120 seconds were used to calculate the ranges below. However, despite the variation in exposure duration, ranges were almost identical across these durations and therefore were combined and summarized by bin in the table below. General source levels, durations, and other characteristics of these systems are described in Section 3.0.3.1.1 (Sonar and Other Transducers).

3.9.3.1.2.3 Impacts from Sonar and Other Transducers Under Alternative 1

Impacts from Sonar and Other Transducers Under Alternative 1 for Training Activities

Sonar and other transducers emit sound waves into the water to detect objects, safely navigate, and communicate. Use of sonar and other transducers would typically be transient and temporary. General categories and characteristics of sonar systems and the number of hours these sonars would be operated during training under Alternative 1 are described in Section 3.0.3.1.1 (Sonar and Other Transducers). Activities using sonars and other transducers would be conducted as described in Chapter 2 (Description of Proposed Action and Alternatives) and Appendix A (Navy Activities Descriptions). Overall use of sonar and other transducers in this Supplement EIS/OEIS compared with the totals analyzed in the 2015 NWTT Final EIS/OEIS are described in Tables 3.0-2 and 3.0-3.

Only a few species of shad within the Clupeidae family, subfamily Alosinae, are known to be able to detect high-frequency sonar and other transducers (greater than 10 kHz) and are considered a part of the fish hearing group for species with a swim bladder that have high-frequency hearing. However, these species are not present in the NWTT Study Area. Other marine fishes would probably not detect these high-frequency sounds and therefore would not experience masking, physiological stress, or behavioral disturbance.

Table 3.9-4: Ranges to Temporary Threshold Shift from Four Representative Sonar Bins

Fish Hearing Group	*Range to Effects (meters)*			
	Sonar Bin LF4 Low-frequency	*Sonar Bin MF1 Hull-mounted surface ship sonars (e.g., AN/SQS-53C and AN/SQS-61)*	*Sonar Bin MF4 Helicopter-deployed dipping sonars (e.g., AN/AQS-22)*	*Sonar Bin MF5 Active acoustic sonobuoys (e.g., DICASS)*
Fishes without a swim bladder	NR	NR	NR	NR
Fishes with a swim bladder not involved in hearing	0	NR	NR	NR
Fishes with a swim bladder involved in hearing	0	6 (0–11)	0	0
Fishes with a swim bladder and high frequency hearing	0	6 (0–11)	0	0

Notes: Ranges to TTS represent modeled predictions in different areas and seasons within the Study Area. The average range to TTS is provided as well as the minimum to the maximum range to TTS in parenthesis. Where only one number is provided the average, minimum, and maximum ranges to TTS are the same.
LF = low-frequency, MF = mid-frequency, NR = no criteria are available and therefore no range to effects are estimated.

Under Alternative 1, training activities would fluctuate each year to account for the natural variation of training cycles and deployment schedules. Most anti-submarine warfare activities involving submarines or submarine targets occur in waters greater than 600 feet [ft.] (approximately 180 m) deep and would typically be used beyond 12 NM from shore. Exceptions include sonar maintenance and system checks while transiting to or from port. Some unit-level anti-submarine warfare training requirements would be conducted using synthetic means (e.g., simulators) or would be completed through other training exercises. However, training activities using low- and some mid-frequency sonars within most marine and anadromous fishes hearing range (< 2 kHz) would not fluctuate between years. Overall, use of sources in this frequency range are less common during training activities than testing activities, and occur less often than sources with higher frequency content. Although training activities using sonar and other transducers could occur throughout the Study Area, low-and some mid-frequency sonars within the hearing range of most fish only occur in the Offshore Area.

As discussed above, most marine fish species are not expected to detect sounds in the mid-frequency range (above a few kHz) of most operational sonars. The fish species that are known to detect mid-frequencies (i.e., those with swim bladders, including some sciaenids [drum], most clupeids [herring, shad], and potentially deep-water fish such as myctophids [lanternfish]) do not have their best sensitivities in the range of the operational sonars. Thus, fishes may only detect the most powerful systems, such as hull-mounted sonar, within a few kilometers; and most other, less powerful mid-frequency sonar systems, for a kilometer or less. Fishes with a swim bladder involved in hearing and with high-frequency hearing are more susceptible to hearing loss due to exposure to mid-frequency sonars. However, the maximum estimated range to TTS for these fish hearing groups is equal to or less than 10 m for only the most powerful sonar bins. Fishes within these hearing groups would have to be very close to the source and the source levels would have to be relatively high in order to experience this effect.

Most mid-frequency active sonars used in the Study Area would not have the potential to substantially mask key environmental sounds or produce sustained physiological stress or behavioral reactions due to the limited time of exposure resulting from the moving sound sources and variable duty cycles. However, it is important to note that some mid-frequency sonars have a high duty cycle or are operated continuously. This may increase the risk of masking, but only for important biological sounds that overlap with the frequency of the sonar being operated. Furthermore, although some species may be able to produce sound at higher frequencies (greater than 1 kHz), vocal marine fishes, such as sciaenids, largely communicate below the range of mid-frequency levels used by most sonars. Any such effects would be temporary and infrequent as a vessel operating mid-frequency sonar transits an area. As such, mid-frequency sonar use is unlikely to impact individuals. Long-term consequences for fish populations due to exposure to mid-frequency sonar and other transducers are not expected.

All marine fish species can likely detect low-frequency sonars and other transducers. However, low-frequency active sonar use is rare during training activities and most low-frequency active operations are conducted in deeper waters, usually beyond the continental shelf break. The majority of fish species, including those that are the most highly vocal, exist on the continental shelf and within nearshore, estuarine areas. However, some species may still be present where low-frequency sonar and other transducers are used. Most low-frequency sonar sources do not have a high enough source level to cause TTS. Although highly unlikely, if TTS did occur, it may reduce the detection of biologically significant sounds but would likely recover within a few minutes to days.

The majority of fish species exposed to sonar and other transducers within near (tens of meters) to far (thousands of meters) distances of the source would be more likely to experience; mild physiological stress; brief periods of masking; behavioral reactions such as startle or avoidance responses, although risk would be low even close to the source; or no reaction. However, based on the information provided in the *ANSI Sound Exposure Guideline* technical report (Popper et al., 2014), the relative risk of these effects at any distance are expected to be low. Due to the transient nature of most sonar operations, overall effects would be localized and infrequent, only lasting a few seconds or minutes. Based on the low level and short duration of potential exposure to low-frequency sonar and other transducers, long-term consequences for fish populations are not expected.

As discussed previously in Section 3.9.2.1 (Hearing and Vocalization) and as shown in Figure 3.9-6, all ESA-listed fish species that occur in the Study Area are capable of detecting sound produced by low- and some mid-frequency (< 2kHz) sonars and other transducers. Pacific eulachon do not have a swim bladder and cannot detect frequencies above 1 kHz. ESA-listed salmon species, rockfish, and green sturgeon have a swim bladder not involved in hearing and may be able to detect some mid-frequency sources below 2 kHz, but they are not particularly sensitive to these frequencies. Therefore, impacts from mid-, high- or very high-frequency sonar and other transducers are not expected for any ESA-listed and proposed species.

All ESA-listed salmon species are present in the Offshore Area throughout some portion of the year. In addition, the ESA-listed Puget Sound Chinook salmon ESU, Hood Canal summer-run chum salmon ESU, Puget Sound DPS of Steelhead, and Coastal-Puget Sound DPS of bull trout also occur in the Inland

Waters. Puget Sound/Georgia Basin DPS of bocaccio and yelloweye rockfish only occur in the Inland Waters. Training activities that use sonar and other transducers with frequency content at or below 2 kHz are not operated in the Inland Waters, therefore fishes that occur in the Inland Waters would not be exposed to these sources. Green sturgeon and Pacific eulachon occur throughout the Study Area and could be exposed to low-frequency sonar in the Offshore Area. There are no low- or mid-frequency (< 2kHz) sources operated in Western Behm Canal during training activities, therefore ESA-listed species that occur there would not be impacted.

Impacts on ESA-listed fishes, if they occur, would be similar to impacts on fishes in general. However, due to the short-term, infrequent and localized nature of these activities, ESA-listed fishes are unlikely to be exposed multiple times within a short period. In addition, physiological and behavioral reactions would be expected to be brief (seconds to minutes) and infrequent based on the low probability of co-occurrence between training activities and these species. Although individuals may be impacted, long-term consequences for populations would not be expected.

Designated critical habitat for the Puget Sound Chinook salmon ESU, Hood Canal Summer-run chum salmon ESU, the Coastal-Puget Sound DPS of bull trout, the Puget Sound/Georgia Basin DPS of bocaccio and yelloweye rockfish, and the Southern DPS of green sturgeon overlap the Study Area in the Inland Waters. In addition, designated critical habitat for bull trout and green sturgeon occur in the nearshore coastal areas of the Study Area. However, most of the physical and biological features for the anadromous ESA-listed species are generally not applicable to the Study Area (e.g., features associated with freshwater riverine habitat). While activities could occur in close proximity to designated critical habitat, no adverse effects to any physical or biological features (e.g., water quality, habitat structure, prey availability, or unobstructed passageways) are anticipated from exposure to sonar and other transducers.

Designated critical habitat for steelhead, coho, sockeye, and Pacific eulachon is not present in the Study Area and would not be impacted.

Pursuant to the ESA, the use of sonar and other transducers during training activities, as described under Alternative 1, may affect ESA-listed salmonids (all ESUs and DPSs) including bull trout (Coastal Puget Sound DPS), Pacific eulachon (Southern DPS), and green sturgeon (Southern DPS). The Navy has consulted with NMFS and USFWS as required by Section 7(a)(2) of the ESA. The use of sonar and other transducers would have no effect on ESA-listed bocaccio rockfish (Puget Sound/Georgia Basin DPS), yelloweye rockfish (Puget Sound/Georgia Basin DPS), or on designated critical habitat for Chinook (Puget Sound ESU), chum (Hood Canal summer-run ESU), bull trout (Coastal Puget Sound DPS), bocaccio rockfish (Puget Sound/Georgia Basin DPS), yelloweye rockfish (Puget Sound/Georgia Basin DPS), and green sturgeon (Southern DPS).

Pursuant to the EFH requirements of the Magnuson-Stevens Fishery Conservation and Management Act and implementing regulations, the use of sonar and other transducers associated with training activities, as described under Alternative 1, may affect EFH species within the Study Area.

Impacts from Sonar and Other Transducers Under Alternative 1 for Testing Activities

General categories and characteristics of sonar systems and the number of hours these sonars would be operated during testing under Alternative 1 are described in Section 3.0.3.1.1 (Sonar and Other Transducers). Activities using sonars and other transducers would be conducted as described in Chapter 2 (Description of Proposed Action and Alternatives) and Appendix A (Navy Activities

Descriptions). Overall use of sonar and other transducers in this Supplemental compared with the totals analyzed in the 2015 NWTT Final EIS/OEIS are described in Tables 2.5-1 and 2.5-2.

Testing activities using sonar and other transducers would occur throughout the Study Area, with the majority of use occurring in the Inland Waters. Low-frequency sources are operated more frequently under testing activities than under training activities, including low- and some mid-frequency sonars (< 2kHz) that operate within most fish hearing ranges. In addition, some new systems using new technologies will be tested under Alternative 1 compared to systems analyzed in the 2015 NWTT Final EIS/OEIS. Although the general impacts from sonar and other transducers under testing would be similar to those described under training, there would be more impacts under testing activities as all marine fishes can detect low frequency sources.

Hearing loss in fishes from exposure to sonar and other transducers is unlikely. Although unlikely, if TTS did occur, it would occur within tens of meters of the source and only in select hearing groups. The majority of fish species exposed to sonar and other transducers within near (tens of meters) to far (thousands of meters) distances of the source would be more likely to experience; mild physiological stress; brief periods of masking; behavioral reactions such as startle or avoidance responses, although risk would be low even close to the source; or no reaction. However, based on the information provided in the *ANSI Sound Exposure Guideline* technical report (Popper et al., 2014), the relative risk of these effects at any distance are expected to be low. Long-term consequences for individual fish are unlikely in most cases because acoustic exposures are intermittent, transient and unlikely to repeat over short periods. Since long-term consequences for most individuals are unlikely, long-term consequences for populations are not expected.

As discussed previously in Section 3.9.2.1 (Hearing and Vocalization) and as shown in Figure 3.9-6, all ESA-listed fish species that occur in the Study Area are capable of detecting sound produced by low- and some mid-frequency (< 2kHz) sonars and other transducers. Pacific eulachon do not have a swim bladder and cannot detect frequencies above 1 kHz. ESA-listed salmon species, rockfish, and green sturgeon have a swim bladder not involved in hearing and may be able to detect some mid-frequency sources below 2 kHz, but they are not particularly sensitive to these frequencies. Therefore, impacts from mid-, high- or very high-frequency sonar and other transducers are not expected for any ESA-listed and proposed species.

All ESA-listed salmon species are present in the Offshore Area throughout the year. In addition, the ESA-listed Puget Sound Chinook salmon ESU, Hood Canal summer-run chum salmon ESU, Puget Sound DPS of steelhead, and Coastal-Puget Sound DPS of bull trout also occur in the Inland Waters. The only species that are present in Western Behm Canal include the Puget Sound ESU, Upper Columbia River spring-run ESU, Lower Columbia River ESU, Upper Willamette River ESU, Snake River spring-summer ESU, and Snake River fall-run Chinook salmon ESUs, as well as the Lower Columbia and Oregon Coast coho salmon ESU. Puget Sound/Georgia Basin DPS of bocaccio rockfish and yelloweye rockfish only occur in the Inland Waters and would only be exposed to sources in this portion of the Study Area. Green sturgeon and Pacific eulachon occur throughout the Study Area.

Impacts on ESA-listed fishes, if they occur, would be similar to impacts on fishes in general. However, due to the short-term, infrequent and localized nature of these activities, ESA-listed fishes are unlikely to be exposed multiple times within a short period. In addition, physiological and behavioral reactions would be expected to be brief (seconds to minutes) and infrequent based on the low probability of co-occurrence between training activities and these species. Although individuals may be impacted, long-term consequences for populations would not be expected.

Designated critical habitat for the Puget Sound Chinook salmon ESU, Hood Canal summer-run chum salmon ESU, the Coastal-Puget Sound DPS of bull trout, the Puget Sound/Georgia Basin DPS of bocaccio and yelloweye rockfish, and the Southern DPS of green sturgeon overlap the Study Area in the Inland Waters. In addition, designated critical habitat for bull trout and green sturgeon occur in the nearshore coastal areas of the Study Area. However, most of the physical and biological features for the anadromous ESA-listed species are generally not applicable to the Study Area (e.g., features associated with freshwater riverine habitat). While activities could occur in close proximity to designated critical habitat, no adverse effects to any physical or biological features (e.g., water quality, habitat structure, prey availability, or unobstructed passageways) are anticipated from exposure to sonar and other transducers.

Designated critical habitat for steelhead, coho, sockeye, and Pacific eulachon is not present in the Study Area and would not be impacted.

Pursuant to the ESA, the use of sonar and other transducers during testing activities, as described under Alternative 1, may affect ESA-listed salmonids (all ESUs and DPSs) including bull trout (Coastal Puget Sound DPS), bocaccio rockfish (Puget Sound/Georgia Basin DPS), yelloweye rockfish (Puget Sound/Georgia Basin DPS), Pacific eulachon (Southern DPS), and green sturgeon (Southern DPS). The Navy has consulted with NMFS and USFWS as required by Section 7(a)(2) of the ESA. The use of sonar and other transducers during testing activities would have no effect on designated critical habitat for Chinook (Puget Sound ESU), chum (Hood Canal summer-run ESU), bull trout (Coastal Puget Sound DPS), bocaccio rockfish (Puget Sound/Georgia Basin DPS), yelloweye rockfish (Puget Sound/Georgia Basin DPS) and green sturgeon (Southern DPS).

Pursuant to the EFH requirements of the Magnuson-Stevens Fishery Conservation and Management Act and implementing regulations, the use of sonar and other transducers associated with testing activities, as described under Alternative 1, may affect EFH species within the Study Area.

3.9.3.1.2.4 Impacts from Sonar and Other Transducers Under Alternative 2

Impacts from Sonar and Other Transducers Under Alternative 2 for Training Activities

As described in Chapter 2 (Description of Proposed Action and Alternatives), Section 3.0.3.1.1 (Sonar and Other Transducers), and Appendix A (Navy Activities Descriptions), training activities under Alternative 2 reflects the maximum number of activities that could occur within a given year. This would result in an increase in sonar use compared to Alternative 1, however the use of sonars and other transducers equal to or less than 2 kHz would remain the same between Alternative 1 and 2. The locations and general types of predicted impacts would be similar to those described above in Section 3.9.3.1.2.3 (Impacts from Sonar and Other Transducers Under Alternative 1 – Impacts from Sonar and Other Transducers Under Alternative 1 for Training Activities). The hours of use of sonars and other transducers in this Supplemental compared with the totals analyzed in the 2015 NWTT Final EIS/OEIS are described in Tables 2.5-1 and 2.5-2.

Pursuant to the ESA, the use of sonar and other transducers during training activities, as described under Alternative 2, may affect ESA-listed salmonids (all ESUs and DPSs) including bull trout (Coastal Puget Sound DPS), Pacific eulachon (Southern DPS), and green sturgeon (Southern DPS). The Navy has consulted with NMFS and USFWS as required by Section 7(a)(2) of the ESA. The use of sonar and other transducers would have no effect on ESA-listed bocaccio rockfish (Puget Sound/Georgia Basin DPS), yelloweye rockfish (Puget Sound/Georgia Basin DPS), or on designated critical habitat for Chinook (Puget Sound ESU), chum (Hood Canal summer-run ESU), bull trout (Coastal Puget Sound DPS), bocaccio rockfish (Puget Sound/Georgia Basin DPS), yelloweye rockfish (Puget Sound/Georgia Basin DPS), and green sturgeon (Southern DPS).

Pursuant to the EFH requirements of the Magnuson-Stevens Fishery Conservation and Management Act and implementing regulations, the use of sonar and other transducers associated with training activities, as described under Alternative 2, may affect EFH species within the Study Area.

Impacts from Sonar and Other Transducers Under Alternative 2 for Testing Activities

As described in Chapter 2 (Description of Proposed Action and Alternatives), Section 3.0.3.1.1 (Sonar and Other Transducers), and Appendix A (Navy Activities Descriptions), testing activities under Alternative 2 reflects the maximum number of activities that could occur within a given year. This would result in an increase in sonar use compared to Alternative 1, including sonars and other transducers equal to or less than 2 kHz. However, the locations and general types of predicted impacts would be similar to those described above in Section 3.9.3.1.2.3 (Impacts from Sonar and Other Transducers Under Alternative 1 – Impacts from Sonar and Other Transducers Under Alternative 1 for Testing Activities). The hours of use of sonars and other transducers in this Supplemental compared with the totals analyzed in the 2015 NWTT Final EIS/OEIS are described in Tables 2.5-1 and 2.5-2.

Pursuant to the ESA, the use of sonar and other transducers during testing activities, as described under Alternative 2, may affect ESA-listed salmonids (all ESUs and DPSs) including bull trout (Coastal Puget Sound DPS), bocaccio rockfish (Puget Sound/Georgia Basin DPS), yelloweye rockfish (Puget Sound/Georgia Basin DPS), Pacific eulachon (Southern DPS), and green sturgeon (Southern DPS). The Navy has consulted with NMFS and USFWS as required by Section 7(a)(2) of the ESA. The use of sonar and other transducers during testing activities would have no effect on designated critical habitat for Chinook (Puget Sound ESU), chum (Hood Canal summer-run ESU), bull trout (Coastal Puget Sound DPS), bocaccio rockfish (Puget Sound/Georgia Basin DPS), yelloweye rockfish (Puget Sound/Georgia Basin DPS) and green sturgeon (Southern DPS).

Pursuant to the EFH requirements of the Magnuson-Stevens Fishery Conservation and Management Act and implementing regulations, the use of sonar and other transducers associated with testing activities, as described under Alternative 2, may affect EFH species within the Study Area.

3.9.3.1.2.5 Impacts from Sonar and Other Transducers Under the No Action Alternative

Under the No Action Alternative, proposed training and testing activities would not occur. Acoustic stressors, as listed above, would not be introduced into the marine environment. Therefore, existing environmental conditions would either remain unchanged or would improve slightly after cessation of ongoing training and testing activities.

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

3.9.3.1.3 Impacts from Vessel Noise

Fishes may be exposed to noise from vessel movement. A detailed description of the acoustic characteristics and typical sound levels of vessel noise are in Section 3.0.3.1.2 (Vessel Noise). Vessel movements involve transits to and from ports to various locations within the Study Area, including commercial ship traffic as well as recreational vessels in addition to U.S. Navy vessels. Many ongoing and proposed training and testing activities within the Study Area involve maneuvers by various types of surface ships, boats, and submarines (collectively referred to as vessels). Activities may vary slightly from those previously analyzed in the 2015 NWTT Final EIS/OEIS, but the overall determinations presented remain valid. Increases and decreases shown in Tables 2.5-1 and 2.5-2 for proposed activities under Alternative 1 and 2 do not appreciably change the impact conclusions presented in the 2015 NWTT Final EIS/OEIS.

Under the No Action Alternative, proposed training and testing activities would not occur. Acoustic stressors, as listed above, would not be introduced into the marine environment. Therefore, existing environmental conditions would either remain unchanged or would improve slightly after cessation of ongoing training and testing activities.

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

Pursuant to the ESA, vessel noise produced during training and testing activities, as described under Alternatives 1 and 2, may affect ESA-listed salmonids (all ESUs and DPSs) including bull trout (Coastal Puget Sound DPS), bocaccio rockfish (Puget Sound/Georgia Basin DPS), yelloweye rockfish (Puget Sound/Georgia Basin DPS), Pacific eulachon (Southern DPS), and green sturgeon (Southern DPS). The Navy has consulted with NMFS and USFWS as required by Section 7(a)(2) of the ESA. Vessel noise produced during training and testing activities would have no effect on designated critical habitat for Chinook (Puget Sound ESU), chum (Hood Canal summer-run ESU), bull trout (Coastal Puget Sound DPS), bocaccio rockfish (Puget Sound/Georgia Basin DPS), yelloweye rockfish (Puget Sound/Georgia Basin DPS) and green sturgeon (Southern DPS).

Pursuant to the EFH requirements of the Magnuson-Stevens Fishery Conservation and Management Act and implementing regulations, vessel noise produced during training and testing activities, as described under Alternative 1 and Alternative 2, may affect EFH species within the Study Area.

3.9.3.1.4 Impacts from Aircraft Noise

Fishes that occur near or at the waters' surface may be exposed to aircraft noise, although this is considered to be unlikely. Fixed, rotary-wing, and tilt-rotor aircraft are used during a variety of training and testing activities throughout the Study Area. Tilt-rotor impacts would be similar to fixed-wing or helicopter impacts depending which mode the aircraft is in. Most of these sounds would be concentrated around airbases and fixed ranges within the range complex. Aircraft noise could also occur in the waters immediately surrounding aircraft carriers at sea during takeoff and landing. Aircraft produce extensive airborne noise from either turbofan or turbojet engines. An infrequent type of aircraft noise is the sonic boom, produced when the aircraft exceeds the speed of sound. Rotary-wing aircraft (helicopters) produce low-frequency sound and vibration (Pepper et al., 2003). A detailed description of aircraft noise as a stressor is in Section 3.0.3.1.3 (Aircraft Noise).

Activities may vary slightly from those previously analyzed in the 2015 NWTT Final EIS/OEIS. The analysis of impacts from aircraft noise in this Supplemental will supplant the 2015 NWTT Final EIS/OEIS for fishes, and may result in changes to estimated impacts for some species since the 2015 NWTT Final EIS/OEIS.

3.9.3.1.4.1 Methods for Analyzing Impacts from Aircraft Noise

The amount of sound entering the ocean from aircraft would be very limited in duration, sound level, and affected area. Due to the low level of sound that could enter the water from aircraft, hearing loss is not further considered as a potential effect. Potential impacts considered are masking of other biologically relevant sounds, physiological stress, and changes in behavior. Reactions by fishes to these specific stressors have not been recorded however, fishes would be expected to react to aircraft noise as they would react to other transient sounds (e.g., vessel noise).

For this analysis, the Navy assumes that some fish at or near the water surface may exhibit startle reactions to certain aircraft noise if aircraft altitude is low. This could mean a hovering helicopter, for which the sight of the aircraft and water turbulence could also cause a response, or a low-flying or super-sonic aircraft generating enough noise to be briefly detectable underwater or at the air-water interface. Because any fixed-wing aircraft noise would be brief, the risk of masking any sounds relevant to fishes is very low. The *ANSI Sound Exposure Guidelines* for fishes did not consider this acoustic stressor (Popper et al., 2014).

3.9.3.1.4.2 Impacts from Aircraft Noise Under Alternative 1

Impacts from Aircraft Noise Under Alternative 1 for Training Activities

Fishes may be exposed to aircraft-generated noise throughout the Study Area. Characteristics of aircraft noise are described in Section 3.0.3.1.3 (Aircraft Noise). Activities with aircraft would be conducted as described in Chapter 2 (Description of Proposed Action and Alternatives) and Appendix A (Navy Activities Descriptions). Aircraft training activities would usually occur adjacent to Navy installations and in Special Use Airspace within the Study Area.

Under Alternative 1, activities may vary slightly from those previously analyzed in the 2015 NWTT Final EIS/OEIS. Increases and decreases are shown in Tables 2.5-1 and 2.5-2 for proposed activities under Alternative 1 and 2.

In most cases, exposure of fishes to fixed-wing aircraft presence and noise would be brief as the aircraft quickly passes overhead. Fishes would have to be at or near the surface at the time of an overflight to be exposed to appreciable sound levels. Due to the low sound levels in water, it is unlikely that fishes would respond to most fixed-wing aircraft or transiting helicopters. Because most overflight exposure would be brief and aircraft noise would be at low received levels, only startle reactions, if any, are expected in response to low altitude flights. Similarly, the brief duration of most overflight exposures would limit any potential for masking of relevant sounds.

Daytime and nighttime activities involving helicopters may occur for extended periods of time, up to a couple of hours in some areas. During these activities, helicopters would typically transit throughout an area but could also hover over the water. Longer event durations and periods of time where helicopters hover may increase the potential for behavioral reactions, startle reactions, masking, and physiological stress. Low-altitude flights of helicopters during some activities, which often occur under 100 ft. altitude, may elicit a stronger startle response due to the proximity of a helicopter to the water; the slower airspeed and longer exposure duration; and the downdraft created by a helicopter's rotor.

If fish were to respond to aircraft noise, only short-term behavioral or physiological reactions (e.g., avoidance and increased heart rate) would be expected. Therefore, long-term consequences for individuals would be unlikely and long-term consequences for populations are not expected.

As discussed previously in Section 3.9.2.1 (Hearing and Vocalization), all ESA-listed fish species that occur in the Study Area are capable of detecting aircraft noise and could be exposed throughout the Study Area. However, due to the small area within which sound could potentially enter the water and the extremely brief window the sound could be present, exposures of fishes to aircraft noise would be extremely rare and, in the event that they did occur, would be very brief (seconds).

Designated critical habitat for the Puget Sound Chinook salmon ESU, Hood Canal summer-run chum salmon ESU, the Coastal-Puget Sound DPS of bull trout, the Puget Sound/Georgia Basin DPS of bocaccio and yelloweye rockfish, and the Southern DPS of green sturgeon overlap the Study Area in the Inland Waters. In addition, designated critical habitat for bull trout and green sturgeon occur in the nearshore coastal areas of the Study Area. However, most of the physical and biological features for the anadromous ESA-listed species are generally not applicable to the Study Area (e.g., features associated with freshwater riverine habitat). While activities could occur in close proximity to designated critical habitat, no adverse effects to any physical or biological features (e.g., water quality, habitat structure, prey availability, or unobstructed passageways) are anticipated from exposure to aircraft noise.

Designated critical habitat for steelhead, coho, sockeye, and Pacific eulachon is not present in the Study Area and would not be impacted.

Pursuant to the ESA, aircraft noise produced during training activities, as described under Alternative 1, may affect ESA-listed salmonids (all ESUs and DPSs) including bull trout (Coastal Puget Sound DPS), bocaccio rockfish (Puget Sound/Georgia Basin DPS), yelloweye rockfish (Puget Sound/Georgia Basin DPS), Pacific eulachon (Southern DPS), and green sturgeon (Southern DPS). The Navy has consulted with NMFS and USFWS as required by Section 7(a)(2) of the ESA. Aircraft noise produced during training activities would have no effect on designated critical habitat for Chinook (Puget Sound ESU), chum (Hood Canal summer-run ESU), bull trout (Coastal Puget Sound DPS), bocaccio rockfish (Puget Sound/Georgia Basin DPS), yelloweye rockfish (Puget Sound/Georgia Basin DPS), and green sturgeon (Southern DPS).

Pursuant to the EFH requirements of the Magnuson-Stevens Fishery Conservation and Management Act and implementing regulations, aircraft noise produced during training activities, as described under Alternative 1, may affect EFH species within the Study Area.

Impacts from Aircraft Noise Under Alternative 1 for Testing Activities

Characteristics of aircraft noise are described in Section 3.0.3.1.3 (Aircraft Noise). Activities with aircraft would be conducted as described in Chapter 2 (Description of Proposed Action and Alternatives) and Appendix A (Navy Activities Descriptions). Aircraft testing activities would usually occur adjacent to Navy installations and in special use airspace within the Study Area. Under Alternative 2, activities may vary slightly from those previously analyzed in the 2015 NWTT Final EIS/OEIS. Increases and decreases are shown in Tables 2.5-1 and 2.5-2 for proposed activities under Alternative 1 and 2.

Proposed testing activities under Alternative 1 that involve aircraft differ in number and location from training activities under Alternative 1; however, the types and severity of impacts would not be discernible from those described above in Section 3.9.3.1.4.2 (Impacts from Aircraft Noise Under Alternative 1 – Impacts from Aircraft Noise Under Alternative 1 for Training Activities).

Pursuant to the ESA, aircraft noise produced during testing activities, as described under Alternative 1, may affect ESA-listed salmonids (all ESUs and DPSs) including bull trout (Coastal Puget Sound DPS), bocaccio rockfish (Puget Sound/Georgia Basin DPS), yelloweye rockfish (Puget Sound/Georgia Basin DPS), Pacific eulachon (Southern DPS), and green sturgeon (Southern DPS). The Navy has consulted with NMFS and USFWS as required by Section 7(a)(2) of the ESA. Aircraft noise produced during testing activities would have no effect on designated critical habitat for Chinook (Puget Sound ESU), chum (Hood Canal summer-run ESU), bull trout (Coastal Puget Sound DPS), bocaccio rockfish (Puget Sound/Georgia Basin DPS), yelloweye rockfish (Puget Sound/Georgia Basin DPS), and green sturgeon (Southern DPS).

Pursuant to the EFH requirements of the Magnuson-Stevens Fishery Conservation and Management Act and implementing regulations, aircraft noise produced during testing activities, as described under Alternative 1, may affect EFH species within the Study Area.

3.9.3.1.4.3 Impacts from Aircraft Noise Under Alternative 2

Impacts from Aircraft Noise Under Alternative 2 for Training Activities

As discussed in Chapter 2 (Description of Proposed Action and Alternatives), and Section 3.0.3.1.3 (Aircraft Noise), training activities under Alternative 2 include a minor increase in the number of events that involve aircraft as compared to Alternative 1; however, the training locations, types of aircraft, and severity of predicted impacts would not be discernible from those described above in Section 3.9.3.1.4.2 (Impacts from Aircraft Noise Under Alternative 1 – Impacts from Aircraft Noise Under Alternative 1 for Training Activities).

Pursuant to the ESA, aircraft noise produced during training activities, as described under Alternative 2, may affect ESA-listed salmonids (all ESUs and DPSs) including bull trout (Coastal Puget Sound DPS), bocaccio rockfish (Puget Sound/Georgia Basin DPS), yelloweye rockfish (Puget Sound/Georgia Basin DPS), Pacific eulachon (Southern DPS), and green sturgeon (Southern DPS). The Navy has consulted with NMFS and USFWS as required by Section 7(a)(2) of the ESA. Aircraft noise produced during training activities would have no effect on designated critical habitat for Chinook (Puget Sound ESU), chum (Hood Canal summer-run ESU), bull trout (Coastal Puget Sound DPS), bocaccio rockfish (Puget Sound/Georgia Basin DPS), yelloweye rockfish (Puget Sound/Georgia Basin DPS), and green sturgeon (Southern DPS).

Pursuant to the EFH requirements of the Magnuson-Stevens Fishery Conservation and Management Act and implementing regulations, aircraft noise produced during training activities, as described under Alternative 2, may affect EFH species within the Study Area.

Impacts from Aircraft Noise Under Alternative 2 for Testing Activities

As discussed in Chapter 2 (Description of Proposed Action and Alternatives), and Section 3.0.3.1.3 (Aircraft Noise), testing activities under Alternative 2 include a minor increase in the number of events that involve aircraft as compared to Alternative 1; however, the training locations, types of aircraft, and severity of predicted impacts would not be discernible from those described above in Section 3.9.3.1.4.2 (Impacts from Aircraft Noise Under Alternative 1 – Impacts from Aircraft Noise under Alternative 1 for Training Activities).

Pursuant to the ESA, aircraft noise produced during testing activities, as described under Alternative 2, may affect ESA-listed salmonids (all ESUs and DPSs) including bull trout (Coastal Puget Sound DPS), bocaccio rockfish (Puget Sound/Georgia Basin DPS), yelloweye rockfish (Puget Sound/Georgia Basin DPS), Pacific eulachon (Southern DPS), and green sturgeon (Southern DPS). The Navy has consulted with NMFS and USFWS as required by Section 7(a)(2) of the ESA. Aircraft noise produced during testing activities would have no effect on designated critical habitat for Chinook (Puget Sound ESU), chum (Hood Canal summer-run ESU), bull trout (Coastal Puget Sound DPS), bocaccio rockfish (Puget Sound/Georgia Basin DPS), yelloweye rockfish (Puget Sound/Georgia Basin DPS), and green sturgeon (Southern DPS).

Pursuant to the EFH requirements of the Magnuson-Stevens Fishery Conservation and Management Act and implementing regulations, aircraft noise produced during testing activities, as described under Alternative 2, may affect EFH species within the Study Area.

3.9.3.1.4.4 Impacts from Aircraft Noise Under the No Action Alternative

Under the No Action Alternative, proposed training and testing activities would not occur. Acoustic stressors, as listed above, would not be introduced into the marine environment. Therefore, existing environmental conditions would either remain unchanged or would improve slightly after cessation of ongoing training and testing activities.

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

3.9.3.1.5 Impacts from Weapon Noise

Fishes may be exposed to sounds caused by the firing of weapons, objects in flight, and impact of non-explosive munitions on the water's surface, which are described in Section 3.0.3.1.4 (Weapons Noise). In general, these are impulsive sounds (such as those discussed under Section 3.0.3.2, Explosive Stressors) generated in close vicinity to or at the water surface, with the exception of items that are launched underwater. The firing of a weapon may have several components of associated noise. Firing of guns could include sound generated in air by firing a gun (muzzle blast) and a crack sound due to a low amplitude shock wave generated by a supersonic projectile flying through the air. Most in-air sound would be reflected at the air-water interface. Underwater sounds would be strongest just below the surface and directly under the firing point. Any sound that enters the water only does so within a narrow cone below the firing point or path of the projectile. Vibration from the blast propagating through a ship’s hull, the sound generated by the impact of an object with the water surface, and the sound generated by launching an object underwater are other sources of impulsive sound in the water. Sound due to missile and target launches is typically at a maximum at initiation of the booster rocket and rapidly fades as the missile or target travels downrange. Due to the transient nature of most activities that produce weapon noise, overall effects would be localized and infrequent, only lasting a few seconds or minutes. Reactions by fishes to these specific stressors have not been recorded however, fishes would be expected to react to weapon noise as they would react to other transient impulsive sounds.

The Coastal-Puget Sound DPS of bull trout occur in the nearshore coastal areas of the Offshore Area. Exposure to weapons noise in the Offshore Area would be limited to the Quinault Range Site. However, within 50 nautical miles (NM) and 20 NM from shore in the Marine Species Coastal Mitigation Area, the Navy will not conduct explosive and non-explosive large-caliber gunnery training activities, respectively.

Within 12 NM from shore in the Marine Species Coastal Mitigation Area, the Navy will not conduct non-explosive small- and medium-caliber gunnery training activities. These mitigation areas would eliminate the potential that ESA-listed bull trout would be exposed to activities that produce weapons noise; therefore, there would be no effect on ESA-listed bull trout.

Activities may vary slightly from those previously analyzed in the 2015 NWTT Final EIS/OEIS, but the overall determinations presented remain valid. Increases and decreases shown in Tables 2.5-1 and 2.5-2 for activities proposed under Alternative 1 and 2 do not appreciably change the impact conclusions presented in the 2015 NWTT Final EIS/OEIS.

Under the No Action Alternative, proposed training and testing activities would not occur. Acoustic stressors, as listed above, would not be introduced into the marine environment. Therefore, existing environmental conditions would either remain unchanged or would improve slightly after cessation of ongoing training and testing activities.

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

Pursuant to the ESA, weapon noise produced during training and testing activities, as described under Alternatives 1 and 2, may affect ESA-listed salmonids (all ESUs and DPSs) including bull trout (Coastal Puget Sound DPS), bocaccio rockfish (Puget Sound/Georgia Basin DPS), yelloweye rockfish (Puget Sound/Georgia Basin DPS), Pacific eulachon (Southern DPS), and green sturgeon (Southern DPS). The Navy has consulted with NMFS and USFWS as required by Section 7(a)(2) of the ESA. Vessel noise produced during training and testing activities would have no effect on designated critical habitat for Chinook (Puget Sound ESU), chum (Hood Canal summer-run ESU), bull trout (Coastal Puget Sound DPS), bocaccio rockfish (Puget Sound/Georgia Basin DPS), yelloweye rockfish (Puget Sound/Georgia Basin DPS) and green sturgeon (Southern DPS).

Pursuant to the EFH requirements of the Magnuson-Stevens Fishery Conservation and Management Act and implementing regulations, weapon noise produced during training and testing activities, as described under Alternative 1 and Alternative 2, may affect EFH species within the Study Area.

3.9.3.2 Explosive Stressors

Explosions in the water or near the water surface can introduce loud, impulsive, broadband sounds into the marine environment. However, unlike other acoustic stressors, explosives release energy at a high rate, producing a shock wave that can be injurious and even deadly. Therefore, explosive impacts on fishes are discussed separately from other acoustic stressors, even though the analysis of explosive impacts will in part rely on data for fish impacts due to impulsive sound exposure where appropriate.

Explosives are usually described by their net explosive weight, which accounts for the weight and type of explosive material. Additional explanation of the acoustic and explosive terms and sound energy concepts used in this section is found in Appendix D (Acoustic and Explosive Concepts).

This section begins with a summary of relevant data regarding explosive impacts on fishes in Section 3.9.3.2.1 (Background). The ways in which an explosive exposure could result in immediate effects or lead to long-term consequences for an animal are explained in Section 3.0.3.7 (Conceptual Framework for Assessing Effects from Acoustic and Explosive Activities), and this section follows that framework.

Due to the availability of new literature, adjusted sound exposure criteria, and new acoustic effects modeling, the analysis provided in Section 3.9.3.2.2 (Impacts from Explosives) of this Supplemental will supplant the 2015 NWTT Final EIS/OEIS for fishes.

3.9.3.2.1 Background

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

3.9.3.2.1.1 Injury

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

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

Several studies have exposed fish to explosives and examined various metrics in relation to injury susceptibility. Sverdrup (1994) exposed Atlantic salmon (1 to 1.5 kg [2 to 3 lb.]) in a laboratory setting to repeated shock pressures of around 2 megapascals (300 pounds per square inch [psi]) without any immediate or delayed mortality after a week. Hubbs and Rechnitzer (1952) showed that fish with swim bladders exposed to explosive shock fronts (the near-instantaneous rise to peak pressure) were more susceptible to injury when several feet below the water surface than near the bottom. When near the surface, the fish began to exhibit injuries around peak pressure exposures of 40 to 70 psi. However, near the bottom (all water depths were less than 100 ft.) fish exposed to pressures over twice as high exhibited no sign of injury. Yelverton et al. (1975) similarly found that peak pressure was not correlated to injury susceptibility; instead, injury susceptibility of swim bladder fish at shallow depths (10 ft. or less) was correlated to the metric of positive impulse (pascal seconds [Pa-s]), which takes into account both the positive peak pressure, the duration of the positive pressure exposure, and the fish mass, with smaller fish being more susceptible.

Dahl et al. (2020) reported the effects of underwater explosions on one species of Clupeiform fish, Pacific sardines (*Sardinops sagax*), with a physostomous swim bladder (an open swim bladder with direct connection to the gut via pneumatic duct). Fish were stationed at various distances prior to each explosion, in addition to a control group that was not exposed. Necropsies following explosions observed significant injuries, including fat hematoma, kidney rupture, swim bladder rupture, and reproductive blood vessel rupture. While most significant injuries were consistently present at close range (<50 m), there were inconsistent findings at the 50–125 m range, suggesting possible acoustic refraction effects, including waveform paths that were bottom reflected, surface reflected, or a combination of both. Ranges at which injuries were observed within the present study are similar to those estimated by the Navy’s Acoustic Effects Model for fishes with a swim bladder for detonations modeled in Southern California (where the study took place, for ranges see U.S. Department of the Navy, 2018b). The Navy continues to fund similar projects, including survival studies and those examining other types of fish (such as physoclists, species with a closed swim bladder), as they are crucial to consider before extrapolating findings to other fish species.

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

O’Keeffe (1984) provides calculations and contour plots that allow estimation of the range to potential effects of in-water explosions on fish possessing swim bladders using the damage prediction model developed by Goertner (1978). O’Keeffe’s (1984) parameters include the charge weight, depth of burst, and the size and depth of the fish, but the estimated ranges do not take into account unique propagation environments that could reduce or increase the range to effect. The 10 percent mortality range shown below in Table 3.9-5 is the maximum horizontal range predicted by O'Keeffe (1984) for

10 percent of fish suffering injuries that are expected to not be survivable (e.g., damaged swim bladder or severe hemorrhaging). Fish at greater depths and near the surface are predicted to be less likely to be injured because geometries of the exposures would limit the amplitude of swim bladder oscillations. In contrast, detonations at or near the surface (i.e., similar to most Navy activities that utilize bombs and missiles) would result in energy loss at the water-air interface, resulting in lower overall ranges to effect than those predicted here.

In contrast to fishes with swim bladders, fishes without swim bladders have been shown to be more resilient to explosives (Gaspin, 1975; Gaspin et al., 1976; Goertner et al., 1994). For example, some small (average 116 mm length; approximately 1 oz.) hogchokers (*Trinectes maculatus*) exposed less than 5 ft. from a 10 lb. pentolite charge immediately survived the exposure with slight to moderate injuries, and only a small number of fish were immediately killed; however, most of the fish at this close range did suffer moderate to severe injuries, typically of the gills or around the otolithic structures (Goertner et al., 1994).

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

Fitch and Young (1948) also investigated whether a significant portion of fish killed would have sunk and not been observed at the surface. Comparisons of the numbers of fish observed dead at the surface and at the bottom in the same affected area after an explosion showed that fish found dead on the bottom comprised less than 10 percent of the total observed mortality. Gitschlag et al. (2000) conducted a more detailed study of both floating fishes and those that were sinking or lying on the bottom after explosive removal of nine oil platforms in the northern Gulf of Mexico. Results were highly variable. They found that 3 to 87 percent (46 percent average) of the red snapper killed during a blast might float to the surface. Currents, winds, and predation by seabirds or other fishes may be some of the reasons that the magnitude of fish mortality may not have been accurately captured.

There have been few studies of the impact of underwater explosives on early life stages of fish (eggs, larvae, juveniles). Fitch and Young (1948) reported mortality of larval anchovies exposed to underwater blasts off California. Nix and Chapman (1985) found that anchovy and smelt larvae died following the detonation of buried charges. Similar to adult fishes, the presence of a swim bladder contributes to shock wave-induced internal damage in larval and juvenile fish (Settle et al., 2002). Explosive shock wave injury to internal organs of larval pinfish and spot exposed at shallow depths was documented by Settle et al. (2002) and Govoni et al. (2003; 2008) at impulse levels similar to those predicted by Yelverton et al. (1975) for very small fish. Settle et al. (2002) provides the lowest measured received level that injuries have been observed in larval fish. Researchers (Faulkner et al., 2006; Faulkner et al., 2008; Jensen, 2003) have suggested that egg mortality may be correlated with peak particle velocity exposure (i.e., the localized movement or shaking of water particles, as opposed to the velocity of the blast wave), although sufficient data from direct explosive exposures is not available.

Rapid pressure changes could cause mechanical damage to sensitive ear structures due to differential movements of the otolithic structures. Bleeding near otolithic structures was the most commonly observed injury in non-swim bladder fish exposed to a close explosive charge (Goertner et al., 1994).

Table 3.9-5: Range to 10% Mortality from In-Water Explosions for Fishes with a Swim Bladder

Weight of Pentolite (lb.) [NEW, lb.][1]	*Depth of Explosion (ft.) [m]*	*10% Mortality Maximum Range (ft.) [m]*		
		1 oz. Fish	*1 lb. Fish*	*30 lb. Fish*
10 [13]	10 [3]	530 [162]	315 [96]	165 [50]
	50 [15]	705 [214]	425 [130]	260 [79]
	200 [61]	905 [276]	505 [154]	290 [88]
100 [130]	10 [3]	985 [300]	600 [183]	330 [101]
	50 [15]	1,235 [376]	865 [264]	590 [180]
	200 [61]	1,340 [408]	1,225 [373]	725 [221]
1,000 [1,300]	10 [3]	1,465 [447]	1,130 [344]	630 [192]
	50 [15]	2,255 [687]	1,655 [504]	1,130 [344]
	200 [61]	2,870 [875]	2,390 [728]	1,555 [474]
10,000 [13,000]	10 [3]	2,490 [759]	1,920 [585]	1,155 [352]
	50 [15]	4,090 [1,247]	2,885 [879]	2,350 [716]
	200 [61]	5,555 [1,693]	4,153 [1,266]	3,090 [942]

[1] Explosive weights of pentolite converted to net explosive weight using the peak pressure parameters in Swisdak (1978). lb. = pounds, NEW = net explosive weight, m = meter, oz. = ounce.
Data from O'Keeffe (1984)

As summarized by the *ANSI Sound Exposure Guideline* technical report (Popper et al., 2014), exposure to explosive energy poses the greatest potential threat for injury and mortality in marine fishes. Fishes with a swim bladder are more susceptible to injury than fishes without a swim bladder. The susceptibility also probably varies with size and depth of both the detonation and the fish. Fish larvae or juvenile fish may be more susceptible to injury from exposure to explosives.

3.9.3.2.1.2 Hearing Loss

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

As reviewed in the *ANSI Sound Exposure Guideline* technical report (Popper et al., 2014), fishes without a swim bladder, or fishes with a swim bladder not involved in hearing, would be less susceptible to hearing loss (i.e., TTS), even at higher level exposures. Fish with a swim bladder involved in hearing may be susceptible to TTS within very close ranges to an explosive. General research findings regarding TTS in fishes as well as findings specific to exposure to other impulsive sound sources are discussed in Section 3.9.3.1.1.2 (Hearing Loss).

3.9.3.2.1.3 Masking

Masking refers to the presence of a noise that interferes with a fish's ability to hear biologically important sounds including those produced by prey, predators, or other fish in the same species (Myrberg, 1980; Popper et al., 2003). This can take place whenever the noise level heard by a fish exceeds the level of a biologically relevant sound. As discussed in Section 3.0.3.7 (Conceptual Framework for Assessing Effects from Acoustic and Explosive Activities) masking only occurs in the presence of the masking noise and does not persist after the cessation of the noise. Masking may lead to a change in vocalizations or a change in behavior (e.g., cessation of foraging, leaving an area).

There are no direct observations of masking in fishes due to exposure to explosives. The *ANSI Sound Exposure Guideline* technical report (Popper et al., 2014) highlights a lack of data that exist for masking by explosives but suggests that the intermittent nature of explosions would result in very limited probability of any masking effects and if masking were to occur it would only occur during the duration of the sound. General research findings regarding masking in fishes due to exposure to sound are discussed in detail in Section 3.9.3.1.1.3 (Masking). Potential masking from explosives is likely to be similar to masking studied for other impulsive sounds such as air guns.

3.9.3.2.1.4 Physiological Stress

Fishes naturally experience stress within their environment and as part of their life histories. The stress response is a suite of physiological changes that are meant to help an organism mitigate the impact of a stressor. However, if the magnitude and duration of the stress response is too great or too long, then it can have negative consequences to the organism (e.g., decreased immune function, decreased reproduction). Section 3.0.3.7 (Conceptual Framework for Assessing Effects from Acoustic and Explosive Activities) provides additional information on physiological stress and the framework used to analyze this potential impact.

Research on physiological stress in fishes due to exposure to explosive sources is limited. Sverdrup et al. (1994) studied levels of stress hormones in Atlantic salmon after exposure to multiple detonations in a laboratory setting. Increases in cortisol and adrenaline were observed following the exposure, with adrenaline values returning to within normal range within 24 hours. General research findings regarding physiological stress in fishes due to exposure to acoustic sources are discussed in detail in Section 3.9.3.1.1.4 (Physiological Stress). Generally, stress responses are more likely to occur in the presence of potentially threatening sound sources such as predator vocalizations or the sudden onset of impulsive signals. Stress responses may be brief (a few seconds to minutes) if the exposure is short or if fishes habituate or learn to tolerate the noise. It is assumed that any physiological response (e.g., hearing loss or injury) or significant behavioral response is also associated with a stress response.

3.9.3.2.1.5 Behavioral Reactions

As discussed in Section 3.0.3.7 (Conceptual Framework for Assessing Effects from Acoustic and Explosive Activities), any stimuli in the environment can cause a behavioral response in fishes, including sound and energy produced by explosions. Alterations in natural behavior patterns due to exposure to explosions have not been studied as thoroughly, but reactions are likely to be similar to reactions studied for other impulsive sounds such as those produced by air guns (e.g., startle response, changes in swim speed and depth). Impulsive signals, particularly at close range, have a rapid rise time and higher instantaneous peak pressure than other signal types, making them more likely to cause startle or avoidance responses. General research findings regarding behavioral reactions from fishes due to exposure to impulsive sounds, such as those associated with explosions, are discussed in detail in Section 3.9.3.1.1.5 (Behavioral Reactions).

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

3.9.3.2.1.6 Long-Term Consequences

Long-term consequences to a population are determined by examining changes in the population growth rate. For additional information on the determination of long-term consequences, see Section 3.0.3.7 (Conceptual Framework for Assessing Effects from Acoustic and Explosive Activities). Physical effects from explosive sources that could lead to a reduction in the population growth rate include mortality or injury, which could remove animals from the reproductive pool, and temporary hearing impairment or chronic masking, which could affect navigation, foraging, predator avoidance, or communication. The long-term consequences due to individual behavioral reactions, masking and short-term instances of physiological stress are especially difficult to predict because individual experience over time can create complex contingencies, especially for fish species that live for multiple seasons or years. For example, a lost reproductive opportunity could be a measurable cost to the individual; however, short-term costs may be recouped during the life of an otherwise healthy individual. These factors are taken into consideration when assessing risk of long-term consequences.

3.9.3.2.2 Impacts from Explosives

This section analyzes the impacts on fishes due to in-water and in-air explosives that would be used during Navy training and testing activities, synthesizing the background information presented above.

As discussed above, sound and energy from underwater explosions are capable of causing mortality, injury, temporary hearing loss, masking, physiological stress, or a behavioral response, depending on the level and duration of exposure. The death of an animal would eliminate future reproductive potential, which is considered in the analysis of potential long-term consequences to the population. Exposures that result in non-auditory injuries may limit an animal's ability to find food, communicate with other animals, or interpret the surrounding environment. Impairment of these abilities can decrease an individual's chance of survival or affect its ability to reproduce. Temporary threshold shift can also impair an animal's abilities, although the individual may recover quickly with little significant effect.

Although activities may vary from those previously analyzed, the overall determinations presented in the 2015 NWTT Final EIS/OEIS remain valid, but have been improved upon under this current Final Supplemental.

3.9.3.2.2.1 Methods for Analyzing Impacts from Explosives

The Navy performed a quantitative analysis to estimate ranges to effect for fishes exposed to underwater explosives during Navy training and testing activities. Inputs to the quantitative analysis included sound propagation modeling in the Navy's Acoustic Effects Model to the sound exposure criteria and thresholds presented below. Density data for fish species within the Study Area are not currently available; therefore, it is not possible to estimate the total number of individuals that may be affected by explosive activities.

Criteria and Thresholds used to Estimate Impacts on Fishes from Explosives

Mortality and Injury from Explosives

Criteria and thresholds to estimate impacts from sound and energy produced by explosive activities are presented below in Table 3.9-6. In order to estimate the longest range at which a fish may be killed or mortally injured, the Navy based the threshold for mortal injury on the lowest pressure that caused mortalities in the study by Hubbs and Rechnitzer (1952), consistent with the recommendation in the *ANSI Sound Exposure Guideline* technical report (Popper et al., 2014). As described in Section 3.9.3.2.1.1 (Injury), this threshold likely over-estimates the potential for mortal injury. The potential for mortal injury has been shown to be correlated to fish size, depth, and geometry of exposure, which are not accounted for by using a peak pressure threshold. However, until fish mortality models are developed that can reasonably consider these factors across multiple environments, use of the peak pressure threshold allows for a conservative estimate of maximum impact ranges.

Table 3.9-6: Sound Exposure Criteria for Mortality and Injury from Explosives

Fish Hearing Group	*Onset of Mortality*	*Onset of Injury*
	SPL_{peak}	SPL_{peak}
Fishes without a swim bladder	229	220
Fishes with a swim bladder not involved in hearing	229	220
Fishes with a swim bladder involved in hearing	229	220
Fishes with a swim bladder and high-frequency hearing	229	220

Note: SPL_{peak} = Peak sound pressure level.

Due to the lack of detailed data for onset of injury in fishes exposed to explosives, thresholds from impact pile driving exposures (Halvorsen et al., 2012a; Halvorsen et al., 2011, 2012b) were used as a proxy for the analysis in the Atlantic Fleet Training and Testing Final EIS/OEIS (U.S. Department of the Navy, 2018a). Upon re-evaluation during consultation with NMFS, both Navy and NMFS agreed that pile driving thresholds are too conservative and not appropriate to use in the analysis of explosive effects on fishes. Therefore, injury criteria have been revised as follows.

Thresholds for the onset of injury from exposure to an explosion are not currently available and recommendations in the *ANSI Sound Exposure Guideline* technical report (Popper et al., 2014) only provide qualitative criteria for consideration. Therefore, available data from existing explosive studies were reviewed to provide a conservative estimate for a threshold to the onset of injury (Gaspin, 1975; Gaspin et al., 1976; Hubbs & Rechnitzer, 1952; Settle et al., 2002; Yelverton et al., 1975).

It is important to note that some of the available literature is not peer-reviewed and may have some caveats to consider when reviewing the data (e.g., issues with controls, limited details on injuries observed, etc.) but this information may still provide a better understanding of where injurious effects would begin to occur specific to explosive activities. The lowest threshold at which injuries were observed in each study were recorded and compared for consideration in selecting criteria. As a conservative measure, the absolute lowest peak sound pressure level recorded that resulted in injury, observed in exposures of larval fishes to explosions (Settle et al., 2002), was selected to represent the threshold to injury.

The injury threshold is consistent across all fish regardless of hearing groups due to the lack of rigorous data for multiple species. As discussed throughout Section 3.9.3.2.1.1 (Injury), it is important to note that these thresholds may be overly conservative, as there is evidence that fishes exposed to higher thresholds than those in Table 3.9-6 have shown no signs of injury (depending on variables such as the weight of the fish, size of the explosion, and depth of the cage (Gaspin, 1975; Gaspin et al., 1976; Hubbs & Rechnitzer, 1952; Settle et al., 2002; Yelverton et al., 1975). It is likely that adult fishes and fishes without a swim bladder would be less susceptible to injury than more sensitive hearing groups (i.e., fishes with a swim bladder) and larval fish.

The number of fish killed by an in-water explosion would depend on the population density near the blast, as well as factors discussed throughout Section 3.9.3.2.1.1 (Injury) such as net explosive weight, depth of the explosion, and fish size. For example, if an explosion occurred in the middle of a dense school of fish, a large number of fish could be killed. However, the probability of this occurring is low based on the patchy distribution of dense schooling fish. Stunning from pressure waves could also temporarily immobilize fish, making them more susceptible to predation.

Fragments produced by exploding munitions at or near the surface may present a high-speed strike hazard for an animal at or near the surface. In water, however, fragmentation velocities decrease rapidly due to drag (Swisdak & Montanaro, 1992). Because blast waves propagate efficiently through water, the range to injury from the blast wave would likely extend beyond the range of fragmentation risk.

Hearing Loss from Explosives

Criteria and thresholds to estimate TTS from sound produced by explosive activities are presented below in Table 3.9-7. Direct (measured) TTS data from explosives are not available. Criteria used to define TTS from explosives is derived from data on fishes exposed to seismic air gun signals (Popper et al., 2005) as summarized in the *ANSI Sound Exposure Guideline* technical report (Popper et al., 2014). TTS has not been documented in fishes without a swim bladder from exposure to other impulsive sources (pile driving and air guns). Although it is possible that fishes without a swim bladder could receive TTS from exposure to explosives, fishes without a swim bladder are typically less susceptible to hearing impairment than fishes with a swim bladder. If TTS occurs in fishes without a swim bladder, it would likely occur within the range of injury; therefore, no thresholds for TTS are proposed. General research findings regarding hearing loss in fishes as well as findings specific to exposure to other impulsive sound sources are discussed in Section 3.9.3.1.1.2 (Hearing Loss).

Table 3.9-7: Sound Exposure Criteria for Hearing Loss from Explosives

Fish Hearing Group	*TTS (SEL_{cum})*
Fishes with a swim bladder not involved in hearing	> 186
Fishes with a swim bladder involved in hearing	186
Fishes with a swim bladder and high-frequency hearing	186

Notes: TTS = Temporary Threshold Shift, SEL_{cum} = Cumulative sound exposure level (decibel referenced to 1 micropascal squared seconds [dB re 1 μPa^2-s]), > indicates that the given effect would occur above the reported threshold.

As discussed in Section 3.9.3.1.1.2 (Hearing Loss), exposure to sound produced from seismic air guns at a cumulative sound exposure level of 186 dB re 1 μPa^2-s has resulted in TTS in fishes with a swim bladder involved in hearing (Popper et al., 2005). TTS has not occurred in fishes with a swim bladder not involved in hearing and would likely occur above the given threshold in Table 3.9-7.

3.9.3.2.2.2 Impact Ranges for Explosives

The following section provides estimated range to effects for fishes exposed to sound and energy produced by explosives. Ranges are calculated using criteria from Table 3.9-8 and Table 3.9-9 and the Navy Acoustic Effects Model. Most detonations conducted during Navy activities would occur at or near the surface. The Navy Acoustic Effects Model cannot account for the highly non-linear effects of cavitation and surface blow off; therefore, some estimated ranges may be overly conservative. In addition, ranges are conservatively calculated using the maximum net explosive weight within any given bin, even if a specific activity uses a smaller charge size. For example, explosive ordnance disposal activities in the Inland Waters use charges much smaller than 0.1 lb. although ranges in the table below were estimated using a charge size of 0.1 lb. Fishes within these ranges would be predicted to receive the associated effect. Ranges may vary greatly depending on factors such as the cluster size (the number of rounds fired [or buoys dropped] within a very short duration), location, depth, and season of the event.

Table 3.9-8 provides range to mortality and injury for all fishes regardless of hearing group. Only one table (Table 3.9-9) is provided for range to TTS for all fishes with a swim bladder. As discussed in the section above, TTS has not been documented in fishes without a swim bladder and therefore no criteria or range to effect are proposed.

Table 3.9-8: Range to Mortality and Injury for All Fishes from Explosives

Bin[1]	Range to Effects (meters)	
	Onset of Mortality	Onset of Injury
	229 SPL_{peak}	220 SPL_{peak}
E0[2] Inland Waters (Hood Canal)	49 (35–75)	125 (90–220)
E0[2] Inland Waters (Crescent Harbor)	35 (35–45)	100 (95–150)
E1	50 (45–50)	124 (120–140)
E2	64 (60–65)	163 (150–170)
E3 Inland Waters (Hood Canal)	162 (120–260)	358 (160–675)
E3 Inland Waters (Crescent Harbor)	129 (120–180)	400 (230–1,525)
E3 Offshore Area	111 (110–120)	322 (270–600)
E4	150 (140–370)	466 (350–1,025)
E5	177 (170–180)	447 (430–460)
E7	424 (320–1,025)	1,142 (775–2,275)
E8	644 (380–1,275)	1,708 (950–3,275)

Table 3.9-8: Range to Mortality and Injury for All Fishes from Explosives (continued)

Bin[1]	***Range to Effects (meters)***	
	Onset of Mortality	***Onset of Injury***
	229 SPL_{peak}	***220 SPL_{peak}***
E10	644 (625–650)	1,478 (1,275–1,525)
E11	1,287 (725–3,025)	3,913 (2,025–7,275)

[1]Bin (net explosive weight, lb.): E0 (< 0.1), E1 (0.1 – 0.25), E2 (> 0.25 – 0.5), E3 (> 0.5 – 2.5), E4 (> 2.5 – 5), E5 (> 5 – 10), E7 (> 20 – 60), E8 (> 60 – 100), E10 (> 250 – 500), E11 (> 500 – 650)

[2]Estimated ranges for E0 are consistent with measurements from a series of monitoring events during training activities that used explosives in the Inland Waters (Hart, 2012; U. S. Department of the Navy, 2015; U.S. Department of the Navy, 2009, 2013, 2014, 2015a, 2015b, 2015c).

Notes: NEW = net explosive weight, SPL_{peak} = Peak sound pressure level.

Range to effects represent modeled predictions in different areas and seasons within the Action Area. Bin E0 and E3 are the only bins used in the Inland Waters. Bin E3 is used in both the Inland Waters and Offshore Area, therefore ranges to effect are shown for both the Inland Waters and the Offshore Area for this bin. All other range to effects were calculated in the Offshore Area where these bins would be used. Each cell contains the estimated average, minimum, and maximum range to the specified effect.

Table 3.9-9: Range to TTS for Fishes with a Swim Bladder from Explosives

Bin[1]	***Cluster Size***	***Range to Effects (meters)***
		TTS
		SEL_{cum}
E0[2] Inland Waters (Hood Canal)	1	< 59 (50–85)
E0[2] Inland Waters (Crescent Harbor)	1	< 48 (45–50)
E1	1	< 53 (45–55)
E2	1	< 58 (55–60)
E3 Inland Waters (Hood Canal)	1	<259 (160–440)
E3 Inland Waters (Crescent Harbor)	1	<250 (200–600)
E3 Offshore Area	1	< 150 (140–160)

Table 3.9-9: Range to TTS for Fishes with a Swim Bladder from Explosives (continued)

Bin[1]	*Cluster Size*	*Range to Effects (meters)*
		TTS
		SEL_{cum}
E4	2	< 340 (270–750)
E5	1	< 158 (150–200)
	8	< 394 (380–430)
E7	1	< 974 (675–1,775)
E8	1	< 1,110 (725–1,775)
E10	1	< 570 (550–650)
E11	1	< 2,693 (1,525–5,025)

[1]Bin (net explosive weight, lb.): E0 (< 0.1), E1 (0.1–0.25), E2 (> 0.25–0.5), E3 (> 0.5–2.5), E4 (> 2.5–5), E5 (> 5–10), E7 (> 20–60), E8 (> 60–100), E10 (> 250–500), E11 (> 500–650)

[2]Estimated ranges for E0 are consistent with measurements from a series of monitoring events during training activities that used explosives in the Inland Waters (Hart, 2012; U. S. Department of the Navy, 2015; U.S. Department of the Navy, 2009, 2013, 2014, 2015a, 2015b, 2015c).

Notes: NEW = net explosive weight, SEL_{cum} = Cumulative sound exposure level, TTS = Temporary Threshold Shift, "<" indicates that the given effect would occur at distances less than the reported range(s).

Range to effects represent modeled predictions in different areas and seasons within the Action Area. Bin E0 and E3 are the only bins used in the Inland Waters. Bin E3 is used in both the Inland Waters and Offshore Area, therefore ranges to effect are shown for both the Inland Waters and the Offshore Area for this bin. All other range to effects were calculated in the Offshore Area where these bins would be used. Each cell contains the estimated average, minimum, and maximum range to the specified effect.

3.9.3.2.2.3 Impacts from Explosives Under Alternative 1

Impacts from Explosives Under Alternative 1 for Training Activities

Activities using explosives would be conducted as described in Chapter 2 (Description of Proposed Action and Alternatives) and Appendix A (Navy Activities Descriptions). General characteristics, quantities, and net explosive weights of in-water explosives used during training activities under Alternative 1 are provided in Section 3.0.3.2 (Explosive Stressors). The number of explosive sources in this Supplemental compared with the totals analyzed in the 2015 NWTT Final EIS/OEIS are described in Tables 2.5-1 and 2.5-2.

Under Alternative 1, there could be fluctuation in the amount of explosions that would occur annually, although potential impacts would be similar from year to year. Training activities involving explosives would be concentrated in the Offshore Area. The Navy's mitigation requires explosive training to occur at distances greater than 50 NM from shore in the NWTT Offshore Area. A very small amount of mine neutralization training activities would occur in the Inland Areas of the Study Area. There are no training activities that involve the use of explosives in the Western Behm Canal, therefore there would be no impacts on fishes that occur in these areas. In addition, the Navy will implement mitigation to avoid impacts from explosives on seafloor resources in mitigation areas throughout the Study Area (see Appendix K, Geographic Mitigation Assessment, for more details), which will consequently also help avoid potential impacts on fishes that shelter and feed on live hard bottom, artificial reefs, and shipwrecks. The Navy will also implement mitigation measures, including seasonal charge size restrictions and distance-from-shore requirements for explosive mine neutralization activities involving Navy divers specifically to avoid impacts on ESA-listed bull trout and salmonids in NWTT Inland Waters (see Appendix K, Geographic Mitigation Assessment, for more details).

Sound and energy from explosions could result in mortality and injury, on average, for hundreds to even thousands of meters from some of the largest explosions. Exposure to explosions could also result in temporary hearing loss in nearby fishes. The estimated range to each of these effects based on explosive bin size is provided in Table 3.9-8 and Table 3.9-9. Generally, explosives that belong to larger bins (with large net explosive weights) produce longer ranges within each effect category. However, some ranges vary depending upon a number of other factors (e.g., number of explosions in a single event, depth of the charge, etc.). Fishes without a swim bladder, adult fishes, and larger species would generally be less susceptible to injury and mortality from sound and energy associated with explosive activities than small, juvenile or larval fishes. Fishes that experience hearing loss could miss opportunities to detect predators or prey, or show a reduction in interspecific communication.

Some activities involve the use of multiple detonations over a short period of time and could result in repeated exposures of some individual fish. If an individual fish were repeatedly exposed to sound and energy from underwater explosions within a short period of time that lead to severe alterations in natural behavioral patterns or physiological stress, these impacts could lead to long-term consequences for the individual such as reduced survival, growth, or reproductive capacity. If detonations occurred close together (within a few seconds), there could be the potential for masking to occur but this would likely happen at farther distances from the source where individual detonations might sound more continuous. However, training activities involving explosions are generally dispersed in space and time. Consequently, repeated exposure of individual fishes to sound and energy from in-water explosions over the course of a day or multiple days is not likely and most behavioral effects are expected to be short-term (seconds or minutes) and localized. Exposure to multiple detonations over the course of a day would most likely lead to an alteration of natural behavior or the avoidance of that specific area.

As discussed previously in Section 3.9.2.1 (Hearing and Vocalization), all ESA-listed fish species that occur in the Study Area are capable of detecting sound produced by explosives. All ESA-listed salmon species are present in the Offshore Area throughout the year. Adult and juvenile Chinook and chum salmon generally occur in coastal areas along the continental shelf (within approximately 20–32 NM from shore) and therefore would not be exposed to training activities that occur beyond 50 NM from shore. However, individuals from the Puget Sound, Upper Columbia River spring-run, Snake River spring/summer-run Chinook salmon ESU, and the Columbia River chum salmon ESU, are known to move farther offshore and could be exposed to explosives used during training activities. The majority of ESA-listed steelhead populations could occur beyond 50 NM from shore with the exception of the South-Central California Coast DPS and the Southern-California DPS of steelhead, which are not known to occur beyond distances of approximately 30 NM from shore. Therefore, only these two DPSs of steelhead would avoid impacts from training activities due to lack of spatial overlap. The ESA-listed Puget Sound Chinook salmon ESU, Hood Canal summer-run chum salmon ESU, Puget Sound DPS of Steelhead, and Coastal-Puget Sound DPS of bull trout also occur in the Inland Waters. Salmon of all sizes and age classes could be exposed to explosives in these described areas throughout the year depending on specific seasonal migrations. Bocaccio rockfish and yelloweye rockfish only occur in the Inland Waters. Due to their preference for rocky habitats and the extremely low level of training activities that involve the use of explosives that occur in the Inland Waters, the likelihood of exposure to explosions would be rare. Green sturgeon and Pacific eulachon occur throughout the Study Area. As discussed above, there are no explosive activities in Western Behm Canal, therefore ESA-listed species that occur there would not be impacted.

Impacts on ESA-listed fishes, if they occur, would be similar to impacts on fishes in general. However, due to the short-term, infrequent and localized nature of these activities, ESA-listed fishes are unlikely to be exposed multiple times within a short period. In addition, physiological and behavioral reactions would be expected to be brief (seconds to minutes) and infrequent based on the low probability of co-occurrence between training activities and these species. Although individuals may be impacted, long-term consequences for populations would not be expected.

Designated critical habitat for the Puget Sound Chinook salmon ESU, Hood Canal summer-run chum salmon ESU, the Coastal-Puget Sound DPS of bull trout, the Puget Sound/Georgia Basin DPS of bocaccio and yelloweye rockfish, and Southern DPS of green sturgeon overlap the Study Area in the Inland Waters. In addition, designated critical habitat for bull trout and green sturgeon occur in the nearshore coastal areas of the Study Area. However, it is unlikely that training activities involving explosives would occur in portions of the Inland Waters designated as critical habitat, nor would they occur close to shore as explosives are typically detonated 50 NM from shore. In addition, most of the physical and biological features for the anadromous ESA-listed species are generally not applicable to the Study Area (e.g., features associated with freshwater riverine habitat). While activities could occur in close proximity to designated critical habitat, no adverse effects to any physical or biological features (e.g., water quality, habitat structure, prey availability, or unobstructed passageways) are anticipated from exposure to explosives.

Designated critical habitat for steelhead, coho, sockeye, and Pacific eulachon is not present in the Study Area and would not be impacted.

Pursuant to the ESA, the use of explosives during training activities, as described under Alternative 1, may affect ESA-listed Chinook salmon (Puget Sound, Upper Columbia River spring-run, and Snake River spring/summer-run ESU), chum salmon (Hood Canal summer-run ESU), steelhead (Puget Sound, Upper Columbia River, Middle Columbia River, Lower Columbia River, Upper Willamette River, Snake River Basin, Northern California, California Central Valley, and Central California Coast DPS), bull trout (Coastal Puget Sound DPS), bocaccio rockfish (Puget Sound/Georgia Basin DPS), yelloweye rockfish (Puget Sound/Georgia Basin DPS), Pacific eulachon (Southern DPS), and green sturgeon (Southern DPS). In addition, the use of explosives may affect designated critical habitat for Chinook salmon (Puget Sound ESU), chum salmon (Hood Canal summer-run ESU), bull trout (Coastal Puget Sound DPS), bocaccio rockfish (Puget Sound/Georgia Basin DPS), and yelloweye rockfish (Puget Sound/Georgia Basin DPS). The Navy has consulted with NMFS and USFWS as required by Section 7(a)(2) of the ESA. The use of explosives during training activities would have no effect on ESA-listed Chinook salmon (Lower Columbia River, Upper Willamette River, Snake River fall-run, California Coastal, Central Valley spring-run, and Sacramento River winter-run ESU), coho salmon (all ESUs), chum salmon (Columbia River ESU), sockeye salmon (all ESUs), steelhead (South-Central California Coast and Southern California DP), or on designated critical habitat for green sturgeon (Southern DPS).

Pursuant to the EFH requirements of the Magnuson-Stevens Fishery Conservation and Management Act and implementing regulations, the use of explosives associated with training activities, as described under Alternative 1, may affect EFH species within the Study Area.

Impacts from Explosives Under Alternative 1 for Testing Activities

Activities using explosives would be conducted as described in Chapter 2 (Description of Proposed Action and Alternatives) and Appendix A (Navy Activities Descriptions). General characteristics, quantities, and net explosive weights of in-water explosives used during testing activities under Alternative 1 are provided in Section 3.0.3.2 (Explosive Stressors). The number of explosive sources in this Supplemental compared with the totals analyzed in the 2015 NWTT Final EIS/OEIS are described in Tables 2.5-1 and 2.5-2.

Under Alternative 1, there could be fluctuation in the amount of explosions that would occur annually, although potential impacts would be similar from year to year. Testing activities involving explosives would only occur in the Offshore Area. Therefore, there would be no impacts on fishes that occur in the Inland Waters or Western Behm Canal. With one exception, the Navy's mitigation requires explosive testing to occur at distances greater than 50 NM from shore in the NWTT Offshore Area and explosives would occur in the same general locations and in a similar manner as previously analyzed in the 2015 NWTT Final EIS/OEIS. A new mine countermeasure and neutralization testing activity would occur closer to shore than other activities analyzed in the 2015 NWTT Final EIS/OEIS that involved the use of in-water explosives. This activity would occur greater than 3 NM from shore in the Quinault Range Site or greater than 12 NM from shore elsewhere in the Offshore Area but would not occur off the coast of California. These activities would occur approximately two times per year in water depths shallower than 1,000 ft. (typically 300 ft.). Exposure of fish to these activities would be highly dependent on the actual presence of fish populations in the Study Area at the time the activity takes place, which may be limited depending on various species migration patterns. Additionally, the areas in which this activity could occur are small compared to the overall Study Area, further reducing potential spatial overlap.

Explosives are used less frequently under testing activities than under training activities. Overall, the general impacts from explosives under testing would be similar to those described above in Section

3.9.3.2.2.3 (Impacts from Explosives Under Alternative 1 – Impacts from Explosives Under Alternative 1 for Training Activities) in the Offshore Area with the exception of impacts from the mine countermeasures and neutralization testing activity closer to shore. To avoid impacts on sanctuary resources, the Navy will not conduct explosive mine countermeasures and neutralization testing activities in the Olympic Coast National Marine Sanctuary Mitigation Area. In addition, the Navy will implement mitigation to avoid impacts from explosives on seafloor resources in mitigation areas throughout the Study Area (see Appendix K, Geographic Mitigation Assessment, for more details), which will consequently also help avoid potential impacts on fishes that shelter and feed on live hard bottom, artificial reefs, and shipwrecks. The Navy also developed several new mitigation measures for this Supplemental EIS/OEIS for the purpose of avoiding or reducing potential impacts from explosive mine countermeasure and neutralization testing on ESA-listed fishes, including requirements to (1) conduct explosive mine countermeasure and neutralization testing from July 1 through September 30 to the maximum extent practical when operating within 20 NM from shore, (2) conduct a maximum of one explosive Mine Countermeasure and Neutralization Testing event from October 1 through June 30 within 20 NM from shore in the Marine Species Mitigation Area (not to exceed the use of 20 explosives from bin E4 and 3 explosives from bin E7 annually, and not to exceed the use of 60 explosives from bin E4 and 9 explosives from bin E7 over seven years), (3) not conduct explosive Mine Countermeasure and Neutralization Testing event within a new mitigation area known as the Juan de Fuca Eddy Marine Species Mitigation Area, and (4) not use explosives in bin E7 closer than 6 NM from shore in the Quinault Range Site.

As discussed previously in Section 3.9.2.1 (Hearing and Vocalization), all ESA-listed fish species that occur in the Study Area are capable of detecting sound produced by explosives. All ESA-listed salmon species are present in the Offshore Area throughout portions of the year depending on specific seasonal migrations. As a result, the majority of ESA-listed salmonid populations could overlap areas where in-water explosives occur. The notable exceptions include the South-Central California Coast and Southern California DPS of steelhead, which would only occur in the southernmost portion of the Offshore Area off the coast of California where mine countermeasures and neutralization testing activities are not conducted. In addition, the Hood Canal summer-run chum salmon ESU and the Lake Ozette sockeye salmon ESU would only occur in the northernmost portion of the Offshore Area within the Olympic Coast National Marine Sanctuary and the Strait of Juan de Fuca. Because the Navy will not conduct explosive Mine Countermeasure and Neutralization Testing activities within the Olympic Coast National Marine Sanctuary Mitigation Area or Juan de Fuca Eddy Marine Species Mitigation Area (see Appendix K, Geographic Mitigation Assessment, for more details), these two ESUs would not be affected by in-water explosive testing activities. Bocaccio rockfish and yelloweye rockfish only occur in the Inland Waters, and thus would not be affected by explosive testing activities. Green sturgeon and Pacific eulachon occur throughout the Study Area. As discussed above, there are no explosive testing activities in the Inland Waters or Western Behm Canal, therefore ESA-listed species that occur in these portions of the Study Area would not be impacted.

Impacts on ESA-listed fishes, if they occur, would be similar to impacts on fishes in general. However, due to the short-term, infrequent and localized nature of these activities, ESA-listed fishes are unlikely to be exposed multiple times within a short period. There is still the possibility that repeated exposures could occur during successive detonations that are close in proximity to one another. However, unless ESA-listed fishes are close enough to be seriously injured or killed, the effect of a repeated exposure would not affect the overall fitness of an individual. Most reactions, even to multiple detonations, would result in brief startle responses or avoidance of the area where the detonation occurred. Even temporary displacement from important habitats is not expected to affect the fitness of any individual because similar habitat is likely to be available in close proximity. Physiological and behavioral reactions would be expected to be brief (seconds to minutes) and infrequent based on the low probability of co-occurrence between testing activities and these species. Although individuals may be impacted, long-term consequences for populations would not be expected.

Designated critical habitat for the Puget Sound Chinook salmon ESU, Hood Canal summer-run chum salmon ESU, the Coastal-Puget Sound DPS of Bull trout, the Puget Sound/Georgia Basin DPS of bocaccio and yelloweye rockfish, and Southern DPS of green sturgeon overlap the Study Area in the Inland Waters. In addition, designated critical habitat for bull trout and green sturgeon occur in the nearshore coastal areas of the Offshore Area. Since explosives testing does not take place in Inland Waters, these critical habitats would not be affected. In addition, most of the physical and biological features for the anadromous ESA-listed species are generally not applicable to the Study Area (e.g., features associated with freshwater riverine habitat). While activities could occur in close proximity to designated critical habitat, no adverse effects to any physical or biological features (e.g., water quality, habitat structure, prey availability, or unobstructed passageways) are anticipated from exposure to explosives.

Although green sturgeon critical habitat largely occurs in the nearshore coastal areas of the Study Area and most testing activities would occur beyond 50 NM from shore, some mine countermeasure testing activities would occur closer to shore and would therefore overlap a portion green sturgeon critical habitat. Most of the defined physical and biological features would not be affected by explosives (e.g., water flow and water quality). However, the use of explosives within the critical habitat may affect a small number of prey items.

Designated critical habitat for steelhead, coho, sockeye, and Pacific eulachon is not present in the Study Area and would not be impacted.

Pursuant to the ESA, the use of explosives during testing activities, as described under Alternative 1, may affect ESA-listed Chinook salmon (all ESUs), coho salmon (all ESUs), chum salmon (Columbia River ESU), sockeye salmon (Snake River ESU), steelhead (Puget Sound, Upper Columbia River, Middle Columbia River, Lower Columbia River, Upper Willamette River, Snake River Basin, Northern California, California Central Valley, and Central California Coast DPS), bull trout (Coastal Puget Sound DPS), Pacific eulachon (Southern DPS), green sturgeon (Southern DPS), and designated critical habitat for green sturgeon (Southern DPS). The Navy has consulted with NMFS and USFWS as required by Section 7(a)(2) of the ESA. The use of explosives during testing activities would have no effect on ESA-listed chum salmon (Hood Canal summer-run ESU), sockeye salmon (Lake Ozette ESU)], steelhead (South-Central California Coast and Southern California DPS), bocaccio rockfish (Puget Sound/Georgia Basin DPS), yelloweye rockfish (Puget Sound/Georgia Basin DPS), or on designated critical habitat for Chinook salmon (Puget Sound ESU), chum salmon (Hood Canal ESU), bocaccio rockfish (Puget Sound/Georgia Basin DPS), yelloweye rockfish (Puget Sound/Georgia Basin DPS), or bull trout (Coastal Puget Sound DPS).

Pursuant to the EFH requirements of the Magnuson-Stevens Fishery Conservation and Management Act and implementing regulations, the use of explosives associated with testing activities, as described under Alternative 1, may affect EFH species within the Study Area.

3.9.3.2.2.4 Impacts from Explosives Under Alternative 2

Impacts from Explosives Under Alternative 2 for Training Activities

As described in Chapter 2 (Description of Proposed Action and Alternatives), Section 3.0.3.2 (Explosive Stressors), and Appendix A (Navy Activities Descriptions), training activities under Alternative 2 reflects the maximum number of training activities that could occur within a given year. This would result in an increase of explosive use compared to Alternative 1. The locations and general types of predicted impacts would be similar to those described above in Section 3.9.3.2.2.3 (Impacts from Explosives Under Alternative 1 – Impacts from Explosives Under Alternative 1 for Training Activities). The number of explosive sources in this Supplemental compared with the totals analyzed in the 2015 NWTT Final EIS/OEIS are described in Tables 2.5-1 and 2.5-2.

Designated critical habitat for steelhead, coho, sockeye, and Pacific eulachon is not present in the Study Area and would not be impacted.

Pursuant to the ESA, the use of explosives during training activities, as described under Alternative 2, may affect ESA-listed Chinook salmon (Puget Sound, Upper Columbia River Spring-Run, and Snake River Spring/Summer-Run ESU), chum salmon (Hood Canal Summer-Run ESU), steelhead (Puget Sound, Upper Columbia River, Middle Columbia River, Lower Columbia River, Upper Willamette River, Snake River Basin, Northern California, California Central Valley, and Central California Coast DPS), bull trout (Coastal Puget Sound DPS), bocaccio rockfish (Puget Sound/Georgia Basin DPS), yelloweye rockfish (Puget Sound/Georgia Basin DPS), Pacific eulachon (Southern DPS), and green sturgeon (Southern DPS). In addition, the use of explosives may affect designated critical habitat for Chinook salmon (Puget Sound ESU), chum salmon (Hood Canal summer-run ESU), bull trout (Coastal Puget Sound DPS), bocaccio rockfish (Puget Sound/Georgia Basin DPS), and yelloweye rockfish (Puget Sound/Georgia Basin DPS). The Navy has consulted with NMFS and USFWS as required by Section 7(a)(2) of the ESA. The use of explosives during training activities would have no effect on ESA-listed Chinook salmon (Lower Columbia River, Upper Willamette River, Snake River fall-run, California Coastal, Central Valley spring-run, and Sacramento River winter-run ESU), coho salmon (all ESUs), chum salmon (Columbia River ESU), sockeye salmon (all ESUs), steelhead (South-Central California Coast and Southern California DP), or on designated critical habitat for green sturgeon (Southern DPS).

Pursuant to the EFH requirements of the Magnuson-Stevens Fishery Conservation and Management Act and implementing regulations, the use of explosives associated with training activities, as described under Alternative 2, may affect EFH species within the Study Area.

Impacts from Explosives Under Alternative 2 for Testing Activities

As described in Chapter 2 (Description of Proposed Action and Alternatives), Section 3.0.3.2 (Explosive Stressors), and Appendix A (Navy Activities Descriptions), testing activities under Alternative 2 reflects the maximum number of testing activities that could occur within a given year. This would result in the same amount of explosive use compared to Alternative 1 for testing activities. The locations and general types of predicted impacts would be similar to those described above in Section 3.9.3.2.2.3 (Impacts from Explosives Under Alternative 1 – Impacts from Explosives Under Alternative 1 for Testing Activities). The number of explosive sources in this Supplemental compared with the totals analyzed in the 2015 NWTT Final EIS/OEIS are described in Tables 2.5-1 and 2.5-2.

Designated critical habitat for steelhead, coho, sockeye, and Pacific eulachon are not present in the Study Area and would not be impacted.

Pursuant to the ESA, the use of explosives during testing activities, as described under Alternative 2, may affect ESA-listed Chinook salmon (all ESUs), coho salmon (all ESUs), chum salmon (Columbia River ESU), sockeye salmon (Snake River ESU), steelhead (Puget Sound, Upper Columbia River, Middle Columbia River, Lower Columbia River, Upper Willamette River, Snake River Basin, Northern California, California Central Valley, and Central California Coast DPS), bull trout (Coastal Puget Sound DPS), Pacific eulachon (Southern DPS), green sturgeon (Southern DPS), and designated critical habitat for green sturgeon (Southern DPS). The Navy has consulted with NMFS and USFWS as required by Section 7(a)(2) of the ESA. The use of explosives during testing activities would have no effect on ESA-listed chum salmon (Hood Canal Summer-Run ESU), sockeye salmon (Lake Ozette ESU)], steelhead (South-Central California Coast and Southern California DPS), bocaccio rockfish (Puget Sound/Georgia Basin DPS), yelloweye rockfish (Puget Sound/Georgia Basin DPS), or on designated critical habitat for Chinook salmon (Puget Sound ESU), chum salmon (Hood Canal ESU), bocaccio rockfish (Puget Sound/Georgia Basin DPS), yelloweye rockfish (Puget Sound/Georgia Basin DPS), or bull trout (Coastal Puget Sound DPS).

Pursuant to the EFH requirements of the Magnuson-Stevens Fishery Conservation and Management Act and implementing regulations, the use of explosives associated with testing activities, as described under Alternative 2, may affect EFH species within the Study Area.

3.9.3.2.2.5 Impacts from Explosives Under the No Action Alternative

Under the No Action Alternative, proposed training and testing activities would not occur. Explosive stressors, as listed above, would not be introduced into the marine environment. Therefore, existing environmental conditions would either remain unchanged or would improve slightly after cessation of ongoing training and testing activities.

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

3.9.3.3 Energy Stressors

The energy stressors that may impact fishes include in-water electromagnetic devices and high-energy lasers. Only one new energy stressor (high-energy lasers) used in testing activities differs from the energy stressors that were previously analyzed in the 2015 NWTT Final EIS/OEIS. Use of low-energy lasers was analyzed and dismissed as an energy stressor in the 2015 NWTT Final EIS/OEIS in Section 3.0.5.3.2.2 (Lasers). However, at that time high-energy laser weapons were not part of the proposed action for the Study Area.

As discussed in Section 3.0.3.3.2.2 (High-Energy Lasers), high-energy lasers can be divided into high-energy laser weapons and laser-based optical communication systems. High-energy laser weapons are designed to disable surface targets, rendering them immobile. High-energy lasers lose a significant amount of energy within only a few centimeters (cm) from the surface. Laser-based optical communication systems penetrate the water and at least 1.7 percent of a laser beam is scattered and reflected at the surface. Once it is underwater, the light will lose power at an exponential rate due to scattering and absorption (Ulrich, 2004). A minimum of 86 percent of light will be lost over 10 m for blue-green wavelengths; significantly more would be lost for other wavelength lasers. The primary concern for both high-energy laser weapons and laser-based communication systems is the potential for a fish to be struck with the laser beam at or near the water's surface, where extended exposure could result in injury or death. Fish could be exposed to a laser only if the beam missed the target. Should the laser strike the sea surface, individual fish at or near the surface could be exposed. The potential for exposure to a high-energy laser beam decreases as the water depth increases. Most fish are unlikely to be exposed to laser activities because they primarily occur more than a few meters below the sea surface.

3.9.3.3.1 Impacts from In-Water Electromagnetic Devices

3.9.3.3.1.1 Impacts from In-Water Electromagnetic Devices Under Alternative 1

Impacts from In-Water Electromagnetic Devices Under Alternative 1 for Training Activities

Under Alternative 1, the number of proposed training activities involving the use of in-water electromagnetic devices would remain the same (Table 3.0-9) as those proposed in the 2015 NWTT Final EIS/OEIS. The activities would occur in the same locations and in a similar manner as were analyzed previously. Therefore, the impacts on fishes would be the same. As stated in the 2015 NWTT Final EIS/OEIS, the impact of in-water electromagnetic devices on fishes would be inconsequential because (1) the range of impact (i.e., greater than earth's magnetic field) is small (i.e., 13 ft. [3.9 m] from the source), (2) the electromagnetic components of these activities are limited to simulating the electromagnetic signature of a vessel as it passes through the water, and (3) the electromagnetic signal is temporally variable and would cover only a small spatial range during each activity in the Study Area.

Some fishes could have a detectable response to electromagnetic exposure, but any impacts would be temporary and would not impact an individual's growth, survival, annual reproductive success, or lifetime reproductive success (i.e., fitness). Fitness refers to changes in an individual's growth, survival, annual reproductive success, or lifetime reproductive success. Electromagnetic exposure of eggs and larvae of sensitive bony fishes would be low relative to their total ichthyoplankton biomass (Able and Fahay 1998). Therefore, potential impacts on recruitment are not be expected.

Designated critical habitat for steelhead, coho, sockeye, and Pacific eulachon is not present in the Study Area and would not be impacted.

Pursuant to the ESA, the use of in-water electromagnetic devices during training activities, as described under Alternative 1, may affect ESA-listed salmonid species, green sturgeon (Southern DPS), bocaccio rockfish (Puget Sound/Georgia Basin DPS), and yelloweye rockfish (Puget Sound/Georgia Basin DPS). The Navy has consulted with NMFS and USFWS, as required by section 7(a)(2) of the ESA. The use of in-water electromagnetic devices would have no effect on bull trout (Coastal Puget Sound DPS) and no effect on critical habitat for Chinook (Puget Sound ESU), chum salmon (Hood Canal summer-run ESU), green sturgeon, bull trout, bocaccio rockfish, and yelloweye rockfish.

Pursuant to the EFH requirements of the Magnuson-Stevens Fishery Conservation and Management Act and implementing regulations, the use of in-water electromagnetic devices associated with training activities, as described under Alternative 1, may affect EFH species within the Study Area.

Impacts from In-Water Electromagnetic Devices Under Alternative 1 for Testing Activities

No in-water electromagnetic devices are proposed for testing activities under Alternative 1.

3.9.3.3.1.2 Impacts from In-Water Electromagnetic Devices Under Alternative 2

Impacts from In-Water Electromagnetic Devices Under Alternative 2 for Training Activities

Under Alternative 2, the number of proposed training activities involving the use of in-water electromagnetic devices would remain the same as Alternative 1 (Table 3.0-9) and those proposed in the

2015 NWTT Final EIS/OEIS. The activities would occur in the same locations and in a similar manner as were analyzed previously. Therefore, the impacts on fishes would be the same as those described above for Alternative 1 and presented in the 2015 NWTT Final EIS/OEIS. As described above for Alternative 1, marine fishes may be exposed to in-water electromagnetic devices during training activities. As stated in the 2015 NWTT Final EIS/OEIS, in-water electromagnetic devices would not cause any potential risk to fishes because (1) the range of impact (i.e., greater than earth's magnetic field) is small (i.e., 13 ft. [3.9 m] from the source), (2) the electromagnetic components of these activities are limited to simulating the electromagnetic signature of a vessel as it passes through the water, and (3) the electromagnetic signal is temporally variable and would cover only a small spatial range during each activity in the Study Area.

Some fishes could have a detectable response to electromagnetic exposure, but any impacts would be temporary and would not impact an individual's growth, survival, annual reproductive success, or lifetime reproductive success (i.e., fitness). Fitness refers to changes in an individual's growth, survival, annual reproductive success, or lifetime reproductive success. Electromagnetic exposure of eggs and larvae of sensitive bony fishes would be low relative to their total ichthyoplankton biomass (Able and Fahay 1998). Therefore, potential impacts on recruitment are not be expected.

Designated critical habitat for steelhead, coho, sockeye, and Pacific eulachon is not present in the Study Area and would not be impacted.

Pursuant to the ESA, the use of in-water electromagnetic devices during training activities, as described under Alternative 2, may affect ESA-listed salmonid species, green sturgeon (Southern DPS), bocaccio rockfish (Puget Sound/Georgia Basin DPS), and yelloweye rockfish (Puget Sound/Georgia Basin DPS). The use of in-water electromagnetic devices would have no effect on bull trout (Coastal Puget Sound DPS) and no effect on critical habitat for Chinook (Puget Sound ESU), chum salmon (Hood Canal summer-run ESU), green sturgeon, bull trout, bocaccio rockfish and yelloweye rockfish.

Pursuant to the EFH requirements of the Magnuson-Stevens Fishery Conservation and Management Act and implementing regulations, the use of in-water electromagnetic devices associated with training activities, as described under Alternative 1, may affect EFH species within the Study Area.

Impacts from In-Water Electromagnetic Devices Under Alternative 2 for Testing Activities

No in-water electromagnetic devices are proposed for testing activities under Alternative 2.

3.9.3.3.1.3 Impacts from In-Water Electromagnetic Devices Under the No Action Alternative

Under the No Action Alternative, proposed training and testing activities would not occur. Energy stressors, as listed above, would not be introduced into the marine environment. In-water electromagnetic devices as listed above would not be introduced into the marine environment. Therefore, existing environmental conditions would either remain unchanged or would improve slightly after cessation of ongoing training and testing activities.

Discontinuing the training and testing activities would result in fewer energy stressors within the marine environment where training and testing activities have historically been conducted. Therefore, discontinuing training and testing activities under the No Action Alternative would lessen the potential for energy impacts on individual fish, but would not measurably improve the status of fish populations or subpopulations.

3.9.3.3.2 Impacts from High-Energy Lasers

High-Energy Lasers were not proposed for use in the 2015 NWTT Final EIS/OEIS.

As discussed in Section 3.0.3.3.2.2 (High-Energy Lasers), high-energy laser weapons testing activities involve evaluating the effectiveness of a high-energy laser deployed from a surface ship or helicopter to create small but critical failures in potential targets from short ranges.

This section analyzes the potential impacts of high-energy laser weapons on marine fishes. The primary concern for high-energy weapons testing is the potential for a fish to be struck by a high-energy laser beam at or near the water's surface, which could result in injury or death, resulting from traumatic burns from the beam. Fish could be exposed to a laser only if the beam missed the target. Should the laser strike the sea surface, individual fish at or near the surface could be exposed. The potential for exposure to a high-energy laser beam decreases as the water depth increases. Most fish are unlikely to be exposed to laser activities because they primarily occur more than a few meters below the sea surface.

3.9.3.3.2.1 Impacts from High-Energy Lasers Under Alternative 1

Impacts from High-Energy Lasers Under Alternative 1 for Training Activities

No high-energy lasers are proposed for training activities under Alternative 1.

Impacts from High-Energy Lasers Under Alternative 1 for Testing Activities

As discussed in Section 3.0.3.3.2.2 (High-Energy Lasers) and shown in Table 3.0-10, under Alternative 1 there would be up to 55 testing activities per year involving the use of high-energy lasers. One of those 55 activities is a test of a laser-based optical communication system, which was discussed in Section 3.0.3.3.2.2 and dismissed from further evaluation. The remaining 54 annual testing activities would involve the use of high-energy laser weapons in the Offshore portion of the Study Area. Fish species may be exposed to high-energy lasers. Fishes are unlikely to be exposed to high-energy lasers based on (1) the relatively low number of events (54 per year throughout the entire Study Area), (2) the very localized potential impact area of the laser beam, (3) the temporary duration of potential impact (seconds), (4) the low probability of fish at or near the surface at the exact time and place a laser misses its target, and (5) the low probability of a laser missing its target.

Designated critical habitat for steelhead, coho, sockeye, and Pacific eulachon is not present in the Study Area and would not be impacted.

Pursuant to the ESA, the use of high-energy laser weapons during testing activities, as described under Alternative 1, may affect ESA-listed salmonid species, green sturgeon (Southern DPS), and Pacific eulachon. The Navy has consulted with NMFS and USFWS, as required by section 7(a)(2) of the ESA. The use of high-energy laser weapons would have no effect on bull trout (Coastal Puget Sound DPS), bocaccio rockfish (Puget Sound/Georgia Basin DPS) and yelloweye rockfish (Puget Sound/Georgia Basin DPS), and would have no effect on critical habitat for Chinook (Puget Sound ESU), chum salmon (Hood Canal summer-run ESU), green sturgeon, bull trout, bocaccio rockfish, and yelloweye rockfish.

Pursuant to the EFH requirements of the Magnuson-Stevens Fishery Conservation and Management Act and implementing regulations, the use of high-energy lasers associated with testing activities, as described under Alternative 1, may affect EFH species within the Study Area.

3.9.3.3.2.2 Impacts from High-Energy Lasers under Alternative 2

Impacts from High-Energy Lasers Under Alternative 2 for Training Activities

No high-energy lasers are proposed for training activities under Alternative 2.

Impacts from High-Energy Lasers Under Alternative 2 for Testing Activities

As shown in Table 3.0-10, a total 54 testing activities involving the use of high-energy laser weapons are proposed to be conducted in the Offshore Area under Alternative 2, the same as under Alternative 1. As stated above, this represents a new activity not covered in the 2015 NWTT Final EIS/OEIS. Therefore, the impacts would be the same as described under Alternative 1.

Pursuant to the ESA, the use of high-energy laser weapons during testing activities, as described under Alternative 2, may affect ESA-listed salmonid species, green sturgeon (Southern DPS), and Pacific eulachon. The use of high-energy laser weapons would have no effect on bull trout (Coastal Puget Sound DPS), bocaccio rockfish (Puget Sound/Georgia Basin DPS) and yelloweye rockfish (Puget Sound/Georgia Basin DPS), and would have no effect on critical habitat for Chinook (Puget Sound ESU), chum salmon (Hood Canal summer-run ESU), green sturgeon, bull trout, bocaccio rockfish, and yelloweye rockfish.

Pursuant to the EFH requirements of the Magnuson-Stevens Fishery Conservation and Management Act and implementing regulations, the use of high-energy lasers associated with testing activities, as described under Alternative 2, may affect EFH species within the Study Area.

3.9.3.3.2.3 Impacts from High-Energy Lasers Under the No Action Alternative

Under the No Action Alternative, proposed training and testing activities would not occur. Energy stressors, as listed above, would not be introduced into the marine environment. Therefore, existing environmental conditions would remain unchanged after cessation of ongoing training and testing activities.

Discontinuing the training and testing activities would result in fewer energy stressors within the marine environment where training and testing activities have historically been conducted. Therefore, discontinuing training and testing activities under the No Action Alternative would lessen the potential for energy impacts on individual fish, but would not measurably improve the status of fish populations or subpopulations.

3.9.3.4 Physical Disturbance and Strike Stressors

The physical disturbance and strike stressors that may impact marine fishes include (1) vessels and in-water devices, (2) military expended materials, and (3) seafloor devices. These stressors remain the same as analyzed in the 2015 NWTT Final EIS/OEIS.

3.9.3.4.1 Impacts from Vessels and In-Water Devices

As stated in the 2015 NWTT Final EIS/OEIS, with few exceptions, activities involving vessels and in-water devices are not intended to contact the seafloor. There is minimal potential strike impact other than bottom-crawling unmanned underwater vehicles. Physical disturbance and strike stressors from vessels and in-water devices, military expended materials, and seafloor devices have the potential to affect all marine fish groups found within the Study Area, although some fish groups may be more susceptible to strike potential than others. In addition, the potential responses to physical strikes are varied, but include behavioral changes such as avoidance, altered swimming speed and direction, physiological stress, and physical injury or mortality.

3.9.3.4.1.1 Impacts from Vessels and In-Water Devices Under Alternative 1

Impacts from Vessels and In-Water Devices Under Alternative 1 for Training Activities

Under Alternative 1, the combined number of proposed training activities involving the movement of vessels and the use of in-water devices would increase (Table 3.0-12 and Table 3.0-13) compared to those proposed in the 2015 NWTT Final EIS/OEIS. Vessel movement would decrease slightly in the Offshore Area (from 1,156 to 1,144 annual activities) and in the Inland Waters (from 368 to 327), so there would still be a net decrease in the Study Area. The activities would occur in the same locations and in a similar manner as were analyzed previously. There is an overall increase in the use of in-water devices (Table 3.0-13), all of which are associated with small, slow-moving unmanned underwater vehicles. Because the increases are to activities in which the in-water devices are small and slow moving, the impacts on fishes would be similar. The proposed increase of approximately 100 in-water devices would not change that conclusion. As stated in the 2015 NWTT Final EIS/OEIS, the risk of a strike from vessels and in-water devices used in training and testing activities on an individual fish would be extremely low because (1) most fish can detect and avoid vessel and in-water device movements, and (2) the types of fish that are likely to be exposed to vessel and in-water device strike are limited and occur in low concentrations where vessels and in-water devices are used. Potential impacts of exposure to vessels and in-water devices are not expected to result in substantial changes to an individual's behavior, fitness, or species recruitment, and are not expected to result in population-level impacts. Therefore, impacts on fish or fish populations would be negligible.

Similar to most other fish species described above, ESA-listed fish species would be able to sense pressure changes in the water column and swim quickly, and are likely to escape collision with vessels and in-water devices.

Designated critical habitat for steelhead, coho, sockeye, and Pacific eulachon is not present in the Study Area and would not be impacted.

Pursuant to the ESA, the use of vessels and in-water devices during training activities, as described under Alternative 1, may affect ESA-listed salmonid species, green sturgeon (Southern DPS), Pacific eulachon, bull trout (Coastal Puget Sound DPS), bocaccio rockfish (Puget Sound/Georgia Basin DPS), and yelloweye rockfish (Puget Sound/Georgia Basin DPS),and may affect critical habitat for Chinook (Puget Sound ESU), chum salmon (Hood Canal summer-run ESU), green sturgeon, bull trout, bocaccio rockfish, and yelloweye rockfish. The Navy has consulted with NMFS and USFWS, as required by section 7(a)(2) of the ESA.

Pursuant to the EFH requirements of the Magnuson-Stevens Fishery Conservation and Management Act and implementing regulations, the use of vessels and in-water devices associated with training activities, as described under Alternative 1, may affect EFH species within the Study Area.

Impacts from Vessels and In-Water Devices Under Alternative 1 for Testing Activities

Under Alternative 1, the combined number of proposed testing activities involving the movement of vessels and the use of in-water devices (Table 3.0-12 and Table 3.0-13) would increase compared to those proposed in the 2015 NWTT Final EIS/OEIS. Vessel movement would increase in the Offshore Area (from 181 to 283 annual activities), and increases slightly in the Inland Waters (from 916 to 918) and Western Behm Canal (60 to 63).

There is also an overall increase in the use of in-water devices during testing activities in the Study Area (Table 3.0-13), all of which are associated with small, slow-moving, and unmanned underwater vehicles. The number of testing activities increases in the Offshore Areas (156 to 215), Inland Waters (576 to 664), and in the western Behm Canal (8 to 19). The proposed increase of in-water devices would not change the conclusion presented in the 2015 NWTT Final EIS/OEIS. The activities would occur in the same locations and in a similar manner as were analyzed previously. In spite of these increases, and as described in the 2015 NWTT Final EIS/OEIS, these vessel and in-water device activities remain unlikely to result in a strike to any marine fish. The proposed increase of vessel and in-water device activities would not change that conclusion. As stated in the 2015 NWTT Final EIS/OEIS, the risk of a strike from vessels and in-water devices used in training and testing activities on an individual fish would be extremely low because (1) most fish can detect and avoid vessel and in-water device movements, and (2) the types of fish that are likely to be exposed to vessel and in-water device strike are limited and occur in low concentrations where vessels and in-water devices are used. Potential impacts of exposure to vessels and in-water devices are not expected to result in substantial changes to an individual's behavior, fitness, or species recruitment, and are not expected to result in population-level impacts. Therefore, impacts on fish or fish populations would be negligible.

Similar to most other fish species described above, ESA-listed fish species would be able to sense pressure changes in the water column and swim quickly, and are likely to escape collision with vessels and in-water devices.

Designated critical habitat for steelhead, coho, sockeye, and Pacific eulachon are not present in the Study Area and would not be impacted.

Pursuant to the ESA, the use of vessels and in-water devices during testing activities, as described under Alternative 1, may affect ESA-listed salmonid species, green sturgeon (Southern DPS), Pacific eulachon, bull trout (Coastal Puget Sound DPS), bocaccio rockfish (Puget Sound/Georgia Basin DPS), and yelloweye rockfish (Puget Sound/Georgia Basin DPS), and may affect critical habitat for Chinook (Puget Sound ESU), chum salmon (Hood Canal summer-run ESU), green sturgeon, bull trout, bocaccio rockfish, and yelloweye rockfish. The Navy has consulted with NMFS and USFWS, as required by section 7(a)(2) of the ESA.

Pursuant to the EFH requirements of the Magnuson-Stevens Fishery Conservation and Management Act and implementing regulations, the use of vessels and in-water devices associated with testing activities, as described under Alternative 1, may affect EFH species within the Study Area.

3.9.3.4.1.2 Impacts from Vessels and In-Water Devices Under Alternative 2

Impacts from Vessels and In-Water Devices Under Alternative 2 for Training Activities

Under Alternative 2, the combined number of proposed training activities involving the movement of vessels and the use of in-water devices would be slightly greater than Alternative 1 (Table 3.0-12 and Table 3.0-13) and greater than those proposed in the 2015 NWTT Final EIS/OEIS. Vessel movement would increase in the Study Area compared to Alternative 1 (1,471 for Alternative 1 compared to 1,658 for Alternative 2), and increases (1,524 to 1,658) compared to levels presented in the 2015 NWTT Final EIS/OEIS (Table 3.0-12).

There would also be a slight total increase in the use of in-water devices compared to Alternative 1 (600 for Alternative 1 compared to 620) and an increase from levels presented in the 2015 NWTT Final EIS/OEIS (496 to 620) (Table 3.0-13). All of the increased in-water device activities are associated with small, slow-moving unmanned underwater vehicles. Because the increases are to activities in which the in-water devices are unlikely to have an impact on marine fishes (small, slow-moving in-water devices), the impacts on fishes would be similar. The proposed increase of in-water devices would not change that conclusion. The activities would occur in the same locations and in a similar manner as were analyzed previously. Under Alternative 2, the risk of a strike from vessels and in-water devices used in training and testing activities on an individual fish would be extremely low because (1) most fish can detect and avoid vessel and in-water device movements, and (2) the types of fish that are likely to be exposed to vessel and in-water device strike are limited and occur in low concentrations where vessels and in-water devices are used. Potential impacts of exposure to vessels and in-water devices are not expected to result in substantial changes to an individual's behavior, fitness, or species recruitment, and are not expected to result in population-level impacts. Therefore, impacts on fish or fish populations would be negligible.

Similar to most other fish species described above, ESA-listed fish species would be able to sense pressure changes in the water column and swim quickly, and are likely to escape collision with vessels and in-water devices.

Designated critical habitat for steelhead, coho, sockeye, and Pacific eulachon is not present in the Study Area and would not be impacted.

Pursuant to the ESA, the use of vessels and in-water devices during training activities, as described under Alternative 2, may affect ESA-listed salmonid species, green sturgeon (Southern DPS), Pacific eulachon, bull trout (Coastal Puget Sound DPS), bocaccio rockfish (Puget Sound/Georgia Basin DPS), and yelloweye rockfish (Puget Sound/Georgia Basin DPS), and may affect critical habitat for Chinook (Puget Sound ESU), chum salmon (Hood Canal summer-run ESU), green sturgeon, bull trout, bocaccio rockfish, and yelloweye rockfish.

Pursuant to the EFH requirements of the Magnuson-Stevens Fishery Conservation and Management Act and implementing regulations, the use of vessels and in-water devices associated with training activities, as described under Alternative 2, may affect EFH species within the Study Area.

<u>Impacts from Vessels and In-Water Devices Under Alternative 2 for Testing Activities</u>

Under Alternative 2, the combined number of proposed testing activities involving the movement of vessels and the use of in-water devices would increase compared to Alternative 1 (Table 3.0-12 and Table 3.0-13) and those proposed in the 2015 NWTT Final EIS/OEIS. Vessel movement would increase slightly in the Offshore Area compared to Alternative 1 (from 283 to 295) and would increase compared to numbers presented in the 2015 NWTT Final EIS/OEIS (from 181 to 295). Vessel movements would increase in the Inland Waters compared to Alternative 1 (from 918 to 1,028) and would increase compared to numbers presented in the 2015 NWTT final EIS/OEIS (from 916 to 1,028). Similarly, vessel movement would increase in the Western Behm Canal (from 63 to 77) compared to Alternative 1 and would increase from 60 to 77 compared to the 2015 NWTT Final EIS/OEIS, resulting in a net increase in the Study Area.

There would also be a slight increase in the use of in-water devices compared to Alternative 1 (898 for Alternative 1 compared to 932) and an increase from levels presented in the 2015 NWTT final EIS/OEIS (740 to 932) (Table 3.0-13). The activities would occur in the same locations and in a similar manner as were analyzed previously. In spite of these increases, and as described in the 2015 NWTT Final EIS/OEIS, these vessel and in-water device activities remain unlikely to result in a strike to any marine fish. The proposed increase of vessel and in-water device activities would not change that conclusion. As stated in the 2015 NWTT Final EIS/OEIS and above under Alternative 1, the impact of vessels and in-water devices on marine fishes would remain inconsequential because (1) most fish can detect and avoid vessel and in-water device movements, and (2) the types of fish that are likely to be exposed to vessel and in-water device strike are limited and occur in low concentrations where vessels and in-water devices are used. Potential impacts of exposure to vessels and in-water devices are not expected to result in substantial changes to an individual's behavior, fitness, or species recruitment, and are not expected to result in population-level impacts.

Designated critical habitat for steelhead, coho, sockeye, and Pacific eulachon is not present in the Study Area and would not be impacted.

Pursuant to the ESA, the use of vessels and in-water devices during testing activities, as described under Alternative 2, may affect ESA-listed salmonid species, green sturgeon (Southern DPS), Pacific eulachon, bull trout (Coastal Puget Sound DPS), bocaccio rockfish (Puget Sound/Georgia Basin DPS), and yelloweye rockfish (Puget Sound/Georgia Basin DPS), and may affect critical habitat for Chinook (Puget Sound ESU), chum salmon (Hood Canal summer-run ESU), green sturgeon, bull trout, bocaccio rockfish, and yelloweye rockfish.

Pursuant to the EFH requirements of the Magnuson-Stevens Fishery Conservation and Management Act and implementing regulations, the use of vessels and in-water devices associated with testing activities, as described under Alternative 2, may affect EFH species within the Study Area.

3.9.3.4.1.3 Impacts from Vessels and In-Water Devices Under the No Action Alternative

Under the No Action Alternative, proposed training and testing activities would not occur. Physical disturbance and strike stressors as listed above would not be introduced into the marine environment. Therefore, existing environmental conditions would either remain unchanged or would improve slightly after cessation of ongoing training and testing activities.

Discontinuing the training and testing activities would result in fewer physical disturbance and strike stressors within the marine environment where training and testing activities have historically been conducted. Therefore, discontinuing training and testing activities under the No Action Alternative would lessen the potential for physical disturbance and strike impacts on individual fish, but would not measurably improve the status of fish populations or subpopulations.

3.9.3.4.2 Impacts from Military Expended Materials

Military expended materials include non-explosive practice munitions (Table 3.0-14), other military materials (Table 3.0-15), high explosives that may result in fragments (Table 3.0-16), and targets (Table 3.0-17).

3.9.3.4.2.1 Impacts from Military Expended Materials Under Alternative 1

Impacts from Military Expended Materials Under Alternative 1 for Training Activities

Under Alternative 1, the number of military materials that would be expended during training activities is generally consistent with the number proposed for use in the 2015 NWTT Final EIS/OEIS. When the amount of military expended materials from (Tables 3.0-14 through 3.0-16) are combined, the number of items proposed to be expended under Alternative 1 decreases compared to ongoing activities. The activities that expend military materials would occur in the same locations and in a similar manner as were analyzed previously. Therefore, the impacts on fishes would be expected to be the same as stated in the 2015 NWTT Final EIS/OEIS and would be inconsequential for the same reasons described above for vessels and in-water devices.

Designated critical habitat for steelhead, coho, sockeye, and Pacific eulachon is not present in the Study Area and would not be impacted.

Pursuant to the ESA, the use of military expended materials during training activities, as described under Alternative 1, may affect ESA-listed salmonid species, green sturgeon (Southern DPS), Pacific eulachon, bull trout (Coastal Puget Sound DPS), bocaccio rockfish (Puget Sound/Georgia Basin DPS), and yelloweye rockfish (Puget Sound/Georgia Basin DPS), and may affect critical habitat for Chinook (Puget Sound ESU), chum salmon (Hood Canal summer-run ESU), green sturgeon, bull trout, bocaccio rockfish, and yelloweye rockfish. The Navy has consulted with NMFS and USFWS, as required by section 7(a)(2) of the ESA.

Pursuant to the EFH requirements of the Magnuson-Stevens Fishery Conservation and Management Act and implementing regulations, the use of military expended materials associated with training activities, as described under Alternative 1, may affect EFH species within the Study Area.

Impacts from Military Expended Materials Under Alternative 1 for Testing Activities

Under Alternative 1, the number of military materials that would be expended during testing activities is generally consistent with the number proposed for use in the 2015 NWTT Final EIS/OEIS. When the amount of military expended materials from (Tables 3.0-14 through 3.0-16) are combined, the number of items proposed to be expended under Alternative 1 increases slightly compared to ongoing activities. Although there are a few new activities such as mine countermeasure and neutralization testing and kinetic energy weapon testing that would generate military expended materials, impacts on fishes would be expected to be the same as those described above and would be inconsequential for the same reasons described above for vessels and in-water devices.

Designated critical habitat for steelhead, coho, sockeye, and Pacific eulachon is not present in the Study Area and would not be impacted.

Pursuant to the ESA, the use of military expended materials during testing activities, as described under Alternative 1, may affect ESA-listed salmonid species, green sturgeon (Southern DPS), Pacific eulachon, bocaccio rockfish (Puget Sound/Georgia Basin DPS), and yelloweye rockfish (Puget Sound/Georgia Basin DPS), and may affect critical habitat for Chinook (Puget Sound ESU), chum salmon (Hood Canal summer-run ESU), green sturgeon, bull trout, bocaccio rockfish, and yelloweye rockfish. The Navy has consulted with NMFS and USFWS, as required by section 7(a)(2) of the ESA.

Pursuant to the EFH requirements of the Magnuson-Stevens Fishery Conservation and Management Act and implementing regulations, the use of military expended materials associated with testing activities, as described under Alternative 1, may affect EFH species within the Study Area.

3.9.3.4.2.2 Impacts from Military Expended Materials Under Alternative 2

Impacts from Military Expended Materials Under Alternative 2 for Training Activities

Under Alternative 2, the number of military materials that would be expended during training activities is generally consistent with the number proposed for use in the 2015 NWTT Final EIS/OEIS. When the amount of military expended materials from Table 3.0-14, Table 3.0-15, and Table 3.0-16 are combined, the number of items proposed to be expended under Alternative 2 increases compared to both Alternative 1 and ongoing activities. The activities that expend military materials would occur in the same locations and in a similar manner as were analyzed previously. Therefore, the impacts on fishes would be expected to be the same. As stated in the 2015 NWTT Final EIS/OEIS, the impact of military expended materials on marine fishes would be inconsequential for the same reasons described above for vessels and in-water devices.

Designated critical habitat for steelhead, coho, sockeye, and Pacific eulachon is not present in the Study Area and would not be impacted.

Pursuant to the ESA, the use of military expended materials during training activities, as described under Alternative 2, may affect ESA-listed salmonid species, green sturgeon (Southern DPS), Pacific eulachon, bull trout (Coastal Puget Sound DPS), bocaccio rockfish (Puget Sound/Georgia Basin DPS), and yelloweye rockfish (Puget Sound/Georgia Basin DPS), and may affect critical habitat for Chinook (Puget Sound ESU), chum salmon (Hood Canal summer-run ESU), green sturgeon, bull trout, bocaccio rockfish, and yelloweye rockfish.

Pursuant to the EFH requirements of the Magnuson-Stevens Fishery Conservation and Management Act and implementing regulations, the use of military expended materials associated with training activities, as described under Alternative 2, may affect EFH species within the Study Area.

Impacts from Military Expended Materials Under Alternative 2 for Testing Activities

Under Alternative 2, the number of military materials that would be expended during testing activities is generally consistent with the number proposed for use in the 2015 NWTT Final EIS/OEIS. When the amount of military expended materials from Tables 3.0-14 through 3.0-16 are combined, the number of items proposed to be expended under Alternative 2 increases compared to Alternative 1 and ongoing activities. Although there are a few new activities such as mine countermeasure and neutralization testing and kinetic energy weapon testing that would generate military expended materials, impacts on marine fishes would be expected to be the same as those described above and would be inconsequential for the same reasons described above for vessels and in-water devices.

Designated critical habitat for steelhead, coho, sockeye, and Pacific eulachon is not present in the Study Area and would not be impacted.

Pursuant to the ESA, the use of military expended materials during testing activities, as described under Alternative 2, may affect ESA-listed salmonid species, green sturgeon (Southern DPS), Pacific eulachon, bull trout (Coastal Puget Sound DPS), bocaccio rockfish (Puget Sound/Georgia Basin DPS) and yelloweye rockfish (Puget Sound/Georgia Basin DPS), and may affect critical habitat for Chinook (Puget Sound ESU), chum salmon (Hood Canal summer-run ESU), green sturgeon, bull trout, bocaccio rockfish, and yelloweye rockfish.

Pursuant to the EFH requirements of the Magnuson-Stevens Fishery Conservation and Management Act and implementing regulations, the use of military expended materials associated with testing activities, as described under Alternative 2, may affect EFH species within the Study Area.

3.9.3.4.2.3 Impacts from Military Expended Materials Under the No Action Alternative

Under the No Action Alternative, proposed training and testing activities would not occur. Physical disturbance and strike stressors as listed above would not be introduced into the marine environment. Therefore, existing environmental conditions would either remain unchanged or would improve slightly after cessation of ongoing training and testing activities.

Discontinuing the training and testing activities would result in fewer physical disturbance and strike stressors within the marine environment where training and testing activities have historically been conducted. Therefore, discontinuing training and testing activities under the No Action Alternative would lessen the potential for physical disturbance and strike impacts on individual fish, but would not measurably improve the status of fish populations or subpopulations.

3.9.3.4.3 Impacts from Seafloor Devices

3.9.3.4.3.1 Impacts from Seafloor Devices Under Alternative 1

Impacts from Seafloor Devices Under Alternative 1 for Training Activities

Under Alternative 1, the number of training activities that include the use of seafloor devices would increase from 10 to 40 compared to ongoing activities, all of which would occur in the Inland Waters (Table 3.0-18) as part of the Precision Anchoring exercise. The activity is comprised of a vessel navigating to a precise, pre-determined location and releasing the ship's anchor to the bottom. The anchor is later recovered and the activity is complete. As discussed in the 2015 NWTT Final EIS/OEIS, it would be highly unlikely that a seafloor device strikes an individual fish because they are able to detect and avoid falling objects through the water column and the dispersed nature of the activity. It is possible, although extremely unlikely, that a fish on the seafloor could be struck by a falling object such as an anchor. Under Alternative 1, training activities involving seafloor devices are not expected to yield any behavioral changes or lasting impacts on the survival, growth, recruitment, or reproduction of fish species at the population level.

Designated critical habitat for steelhead, coho, sockeye, and Pacific eulachon is not present in the Study Area and would not be impacted.

Pursuant to the ESA, the use of seafloor devices during training activities, as described under Alternative 1, may affect ESA-listed salmonid species, green sturgeon (Southern DPS), Pacific eulachon, bull trout (Coastal Puget Sound DPS), bocaccio rockfish (Puget Sound/Georgia Basin DPS), and yelloweye rockfish (Puget Sound/Georgia Basin DPS), and may affect critical habitat for Chinook (Puget Sound ESU), chum salmon (Hood Canal summer-run ESU), green sturgeon, bull trout, bocaccio rockfish, and yelloweye rockfish. The Navy has consulted with NMFS and USFWS, as required by section 7(a)(2) of the ESA.

Pursuant to the EFH requirements of the Magnuson-Stevens Fishery Conservation and Management Act and implementing regulations, the use of seafloor devices associated with training activities, as described under Alternative 1, may affect EFH species within the Study Area.

Impacts from Seafloor Devices Under Alternative 1 for Testing Activities

Under Alternative 1, the total number of testing activities that include the use of seafloor devices (Table 3.0-18) would increase compared to ongoing activities (from 809 to 878). The majority of the activities involve the temporary placement of mine shapes in Inland Waters. As discussed in the 2015 NWTT Final EIS/OEIS, it would be highly unlikely that a seafloor device strikes an individual fish because they are able to detect and avoid falling objects through the water column and the dispersed nature of the activity. It is possible, although extremely unlikely, that a fish on the seafloor could be struck by a falling object such as an anchor. Under Alternative 1, testing activities involving seafloor devices are not expected to yield any behavioral changes or lasting impacts on the survival, growth, recruitment, or reproduction of fish species at the population level.

Designated critical habitat for steelhead, coho, sockeye, and Pacific eulachon is not present in the Study Area and would not be impacted.

Pursuant to the ESA, the use of seafloor devices during testing activities, as described under Alternative 1, may affect ESA-listed salmonid species, green sturgeon (Southern DPS), Pacific eulachon, bull trout (Coastal Puget Sound DPS), bocaccio rockfish (Puget Sound/Georgia Basin DPS), and yelloweye rockfish (Puget Sound/Georgia Basin DPS), and may affect critical habitat for Chinook (Puget Sound ESU), chum salmon (Hood Canal summer-run ESU), bull trout (Coastal Puget Sound DPS), green sturgeon, bull trout, bocaccio rockfish, and yelloweye rockfish. The Navy has consulted with NMFS and USFWS, as required by section 7(a)(2) of the ESA.

Pursuant to the EFH requirements of the Magnuson-Stevens Fishery Conservation and Management Act and implementing regulations, the use of military expended materials associated with testing activities, as described under Alternative 1, may affect EFH species within the Study Area.

3.9.3.4.3.2 Impacts from Seafloor Devices Under Alternative 2

Impacts from Seafloor Devices Under Alternative 2 for Training Activities

Under Alternative 2, the number of training activities that include the use of seafloor devices would be the same as under Alternative 1 (Table 3.0-18) and would increase compared to ongoing activities (from 10 to 40). As described above under Alternative 1, it would be highly unlikely that a seafloor device strikes an individual fish because they are able to detect and avoid falling objects through the water column and the dispersed nature of the activity. It is possible, although extremely unlikely, that a fish on the seafloor could be struck by a falling object such as an anchor. Under Alternative 2, training activities involving seafloor devices are not expected to yield any behavioral changes or lasting impacts on the survival, growth, recruitment, or reproduction of fish species at the population level.

Designated critical habitat for steelhead, coho, sockeye, and Pacific eulachon is not present in the Study Area and would not be impacted.

Pursuant to the ESA, the use of seafloor devices during training activities, as described under Alternative 2, may affect ESA-listed salmonid species, green sturgeon (Southern DPS), Pacific eulachon, bull trout (Coastal Puget Sound DPS), bocaccio rockfish (Puget Sound/Georgia Basin DPS), and yelloweye rockfish (Puget Sound/Georgia Basin DPS), and may affect critical habitat for Chinook (Puget Sound ESU), chum salmon (Hood Canal summer-run ESU), bull trout (Coastal Puget Sound DPS), green sturgeon, bull trout, bocaccio rockfish, and yelloweye rockfish.

Pursuant to the EFH requirements of the Magnuson-Stevens Fishery Conservation and Management Act and implementing regulations, the use of seafloor devices associated with training activities, as described under Alternative 2, may affect EFH species within the Study Area.

Impacts from Seafloor Devices Under Alternative 2 for Testing Activities

Under Alternative 2, the total number of testing activities that include the use of seafloor devices would increase compared to both Alternative 1 (878 to 953) (Table 3.0-18) and ongoing activities (809 to 953). As described above under Alternative 1, it would be highly unlikely that a seafloor device strikes an individual fish because they are able to detect and avoid falling objects through the water column and the dispersed nature of the activity. It is possible, although extremely unlikely, that a fish on the seafloor could be struck by a falling object such as an anchor. Under Alternative 2, testing activities involving seafloor devices are not expected to yield any behavioral changes or lasting impacts on the survival, growth, recruitment, or reproduction of fish species at the population level.

Designated critical habitat for steelhead, coho, sockeye, and Pacific eulachon is not present in the Study Area and would not be impacted.

Pursuant to the ESA, the use of seafloor devices during testing activities, as described under Alternative 2, may affect ESA-listed salmonid species, green sturgeon (Southern DPS), Pacific eulachon, bull trout (Coastal Puget Sound DPS), bocaccio rockfish (Puget Sound/Georgia Basin DPS), and yelloweye rockfish (Puget Sound/Georgia Basin DPS), and may affect critical habitat for Chinook (Puget Sound ESU), chum salmon (Hood Canal summer-run ESU), bull trout (Coastal Puget Sound DPS), green sturgeon, bull trout, bocaccio rockfish, and yelloweye rockfish.

Pursuant to the EFH requirements of the Magnuson-Stevens Fishery Conservation and Management Act and implementing regulations, the use of military expended materials associated with testing activities, as described under Alternative 2, may affect EFH species within the Study Area.

3.9.3.4.3.3 Impacts from Seafloor Devices Under the No Action Alternative

Under the No Action Alternative, proposed training and testing activities would not occur. Physical disturbance and strike stressors as listed above would not be introduced into the marine environment. Therefore, existing environmental conditions would either remain unchanged or would improve slightly after cessation of ongoing training and testing activities.

Discontinuing the training and testing activities would result in fewer physical disturbance and strike stressors within the marine environment where training and testing activities have historically been conducted. Therefore, discontinuing training and testing activities under the No Action Alternative would lessen the potential for physical disturbance and strike impacts on individual fish, but would not measurably improve the status of fish populations or subpopulations.

3.9.3.5 Entanglement Stressors

Entanglement stressors that may impact fishes include (1) fiber optic cables and guidance wires, and (2) decelerators/parachutes. Biodegradable polymer is a new stressor not previously analyzed, but the other two stressors remain the same as analyzed in the 2015 NWTT Final EIS/OEIS.

3.9.3.5.1 Impacts from Wires and Cables

Wires and cables include fiber optic cables, guidance wires, and sonobuoy wires (Table 3.0-19).

3.9.3.5.1.1 Impacts from Wires and Cables Under Alternative 1

Impacts from Wires and Cables Under Alternative 1 for Training Activities

Under Alternative 1, the number of wires and cables that would be expended during training activities (Table 3.0-19) is generally consistent with the number proposed for use in the 2015 NWTT Final EIS/OEIS. No fiber optic cables are used in the Study Area under training, either in the previous analysis or this Supplemental. Two guidance wires are proposed to be expended in the Offshore Area under Alternative 1, compared to none proposed in the previous analysis. No guidance wires would be expended in Inland Waters. As shown in Table 3.0-19, the expenditure of sonobuoy wires in the Offshore Area is proposed to increase slightly (from 8,928 to 9,338), and no sonobuoys are proposed to be used in the Inland Waters, where none were proposed previously. The activities that expend wires and cables would generally occur in the same locations and in a similar manner as were analyzed previously. Because the number and locations of these wires and cables is similar to those analyzed in the 2015 NWTT Final EIS/OEIS, the impacts on fishes would be expected to be the same.

As stated in the 2015 NWTT Final EIS/OEIS, while individual fish susceptible to entanglement would encounter wires and cables, including guidance wires, fiber optic cables, and sonobuoy wires during training and testing activities, the long-term consequences of entanglement are unlikely for either individuals or populations because (1) the encounter rate for wires and cables is low, (2) the types of fishes that are susceptible to these items is limited, (3) there is restricted overlap with susceptible fishes, and (4) the physical characteristics of the wires and cables reduce entanglement risk to fishes compared to monofilament used for fishing gear. Potential impacts from exposure to fiber optic cables and guidance wires are not expected to result in substantial changes to an individual's behavior, fitness, or species recruitment, and are not expected to result in population-level impacts.

Designated critical habitat for steelhead, coho, sockeye, and Pacific eulachon is not present in the Study Area and would not be impacted.

Pursuant to the ESA, the use of wires and cables during with training activities, as described under Alternative 1, may affect ESA-listed salmonid species, green sturgeon (Southern DPS), Pacific eulachon, bull trout (Coastal Puget Sound DPS), bocaccio rockfish (Puget Sound/Georgia Basin DPS) and yelloweye rockfish (Puget Sound/Georgia Basin DPS), and may affect critical habitat for Chinook (Puget Sound ESU), chum salmon (Hood Canal summer-run ESU), green sturgeon, bocaccio rockfish, and yelloweye rockfish. The Navy has consulted with NMFS and USFWS, as required by section 7(a)(2) of the ESA. The use of wires and cables would have no effect on critical habitat for bull trout.

Pursuant to the EFH requirements of the Magnuson-Stevens Fishery Conservation and Management Act and implementing regulations, the use of wires and cables associated with training activities, as described under Alternative 1, may affect EFH species within the Study Area.

Impacts from Wires and Cables Under Alternative 1 for Testing Activities

Under Alternative 1, the total number of wires and cables that would be expended during testing activities (Table 3.0-19) is increased compared to the number proposed for use in the 2015 NWTT Final EIS/OEIS. Fiber optic cables used in the Offshore Area would increase (20 to 36), guidance wires used in both the Offshore Area and the Inland Waters would increase (from 92 to 152 in Offshore Areas and 155 to 230 in Inland Waters), and sonobuoy wires expended would also increase (1,000 to 4,001 in Offshore Areas and 6 to 48 in Inland Waters. Even though the number of wires and cables would increase during testing activities, the locations are similar to those analyzed in the 2015 NWTT Final EIS/OEIS, and impacts on fishes would be expected to be the same.

As stated in the 2015 NWTT Final EIS/OEIS, while individual fish susceptible to entanglement would encounter wires and cables, including guidance wires, fiber optic cables, and sonobuoy wires during training and testing activities, the long-term consequences of entanglement are unlikely for either individuals or populations because (1) the encounter rate for wires and cables is low, (2) the types of fishes that are susceptible to these items is limited, (3) there is restricted overlap with susceptible fishes, and (4) the physical characteristics of the wires and cables reduce entanglement risk to fishes compared to monofilament used for fishing gear. Potential impacts from exposure to fiber optic cables and guidance wires are not expected to result in substantial changes to an individual's behavior, fitness, or species recruitment, and are not expected to result in population-level impacts.

Designated critical habitat for steelhead, coho, sockeye, and Pacific eulachon is not present in the Study Area and would not be impacted.

Pursuant to the ESA, the use of wires and cables during testing activities, as described under Alternative 1, may affect ESA-listed salmonid species, green sturgeon (Southern DPS), Pacific eulachon, bull trout (Coastal Puget Sound DPS), bocaccio rockfish (Puget Sound/Georgia Basin DPS) and yelloweye rockfish (Puget Sound/Georgia Basin DPS), and may affect critical habitat for Chinook (Puget Sound ESU), chum salmon (Hood Canal summer-run ESU), green sturgeon, bocaccio rockfish, and yelloweye rockfish. The Navy has consulted with NMFS and USFWS, as required by section 7(a)(2) of the ESA. The use of wires and cables would have no effect on critical habitat for bull trout.

Pursuant to the EFH requirements of the Magnuson-Stevens Fishery Conservation and Management Act and implementing regulations, the use of wires and cables associated with testing activities, as described under Alternative 1, may affect EFH species within the Study Area.

3.9.3.5.1.2 Impacts from Wires and Cables Under Alternative 2

Impacts from Wires and Cables Under Alternative 2 for Training Activities

Under Alternative 2, the total number of wires and cables that would be expended during training activities (9,380) is generally consistent with the number proposed for use under Alternative 1 (9,340) (Table 3.0-19) and in the 2015 NWTT Final EIS/OEIS (8,928). No fiber optic cables are used in the Study Area under training, either in the previous analysis or this Supplemental. Two guidance wires are proposed to be expended in the Offshore Area under Alternative 2, none were proposed in the previous analysis. As shown in Table 3.0-19, the expenditure of sonobuoy wires in the Offshore Area is proposed to increase slightly (from 9,338 to 9,380), and no sonobuoys are proposed to be used in the Inland Waters, where none were proposed previously. The activities that expend wires and cables would generally occur in the same locations and in a similar manner as were analyzed previously. Because the number and locations of these wires and cables is similar to those analyzed in the 2015 NWTT Final EIS/OEIS, the impacts on fishes would be expected to be the same. As stated in the 2015 NWTT Final EIS/OEIS, the impact of wires and cables on fishes would be inconsequential for the same reasons discussed above under Alternative 1.

Designated critical habitat for steelhead, coho, sockeye, and Pacific eulachon is not present in the Study Area and would not be impacted.

Pursuant to the ESA, the use of wires and cables during with training activities, as described under Alternative 2 may affect ESA-listed salmonid species, green sturgeon (Southern DPS), Pacific eulachon, bull trout (Coastal Puget Sound DPS), bocaccio rockfish (Puget Sound/Georgia Basin DPS) and yelloweye rockfish (Puget Sound/Georgia Basin DPS), and may affect critical habitat for Chinook (Puget Sound ESU), chum salmon (Hood Canal summer-run ESU), green sturgeon, bocaccio rockfish, and yelloweye rockfish. The use of wires and cables would have no effect on critical habitat for bull trout.

Pursuant to the EFH requirements of the Magnuson-Stevens Fishery Conservation and Management Act and implementing regulations, the use of wires and cables associated with training activities, as described under Alternative 2, may affect EFH species within the Study Area.

Impacts from Wires and Cables Under Alternative 2 for Testing Activities

Under Alternative 2, the total number of wires and cables that would be expended during testing activities increases compared to the number proposed for use under Alternative 1 (from 4,616 to 6,862) (Table 3.0-19) and in the 2015 NWTT Final EIS/OEIS (1,395 to 6,862). Fiber optic cables used in the Offshore Area and Inland Waters would be the same as Alternative 1 and increase compared to the 2015 NWTT Final EIS/OEIS. Guidance wires used in the Offshore Area would increase compared to

Alternative 1 (from 152 to 192) and those proposed in the previous analysis (from 92 to 192). Guidance wires in Inland Waters would be the same as Alternative 1 (Table 3.0-19), but increase (from 155 to 230) compared to those proposed in the previous analysis. Sonobuoy wires expended in Offshore Areas would increase compared to Alternative 1 (from 4,001 to 6,207) and in the 2015 NWTT Final EIS/OEIS (from 1,000 to 6,207). Sonobuoy wires expended in Inland Waters would be the same as Alternative 1 (Table 3.0-19) and would increase compared to the 2015 NWTT Final EIS/OEIS (from 6 to 48). The activities that expend wires and cables would generally occur in the same locations and in a similar manner as were analyzed previously. As stated in the 2015 NWTT Final EIS/OEIS, the impact of wires and cables on fishes would be inconsequential for the same reasons discussed above under Alternative 1.

Designated critical habitat for steelhead, coho, sockeye, and Pacific eulachon are not present in the Study Area and would not be impacted.

Pursuant to the ESA, the use of wires and cables during testing activities, as described under Alternative 2, may affect ESA-listed salmonid species, green sturgeon (Southern DPS), Pacific eulachon, bull trout (Coastal Puget Sound DPS), bocaccio rockfish (Puget Sound/Georgia Basin DPS) and yelloweye rockfish (Puget Sound/Georgia Basin DPS), and may affect critical habitat for Chinook (Puget Sound ESU), chum salmon (Hood Canal summer-run ESU), green sturgeon, bocaccio rockfish, and yelloweye rockfish. The use of wires and cables would have no effect on critical habitat for bull trout.

Pursuant to the EFH requirements of the Magnuson-Stevens Fishery Conservation and Management Act and implementing regulations, the use of wires and cables associated with testing activities, as described under Alternative 2, may affect EFH species within the Study Area.

3.9.3.5.1.3 Impacts from Wires and Cables Under the No Action Alternative

Under the No Action Alternative, proposed training and testing activities would not occur. Entanglement stressors as listed above would not be introduced into the marine environment. Therefore, existing environmental conditions would either remain unchanged or would improve slightly after cessation of ongoing training and testing activities.

Discontinuing the training and testing activities would result in fewer entanglement stressors within the marine environment where training and testing activities have historically been conducted. Therefore, discontinuing training and testing activities under the No Action Alternative would lessen the potential for entanglement impacts on individual fish, but would not measurably improve the status of fish populations or subpopulations.

3.9.3.5.2 Impacts from Decelerators/Parachutes

Decelerators/parachutes include small, medium, large, and extra-large decelerator parachutes (Table 3.0-20).

3.9.3.5.2.1 Impacts from Decelerators/Parachutes Under Alternative 1

<u>Impacts from Decelerators/Parachutes Under Alternative 1 for Training Activities</u>

Under Alternative 1, the total number of decelerators/parachutes that would be expended during training activities increases (9,097 to 9,456) compared to the number proposed for use in the 2015 NWTT Final EIS/OEIS. As shown in Table 3.0-20, the expenditure of small size decelerators/parachutes in the Offshore Area is proposed to increase (8,928 to 9,354), and no small decelerators/parachutes are proposed to be used in the Inland Waters, where none were proposed previously. The number of medium decelerators/parachutes in the Offshore Area decreases from 24 to 4, and the number of large decelerators/parachutes in the Offshore Area decreases from 145 to 98 (Table 3.0-20). The activities that expend decelerators/parachutes would generally occur in the same locations and in a similar manner as were analyzed previously. Because the number and locations of these decelerators/parachutes is similar to those analyzed in the 2015 NWTT Final EIS/OEIS, the impacts on fishes would be expected to be the same.

As described in the 2015 NWTT Final EIS/OEIS, it would be very unlikely that fishes would encounter and become entangled in any decelerators/parachutes or sonobuoy accessories. This is mainly due to the size of the range complexes and the resulting widely scattered decelerators/parachutes. If a few individual fish were to encounter and become entangled in a decelerator/parachute, the growth, survival, annual reproductive success, or lifetime reproductive success of the population as a whole would not be impacted directly or indirectly.

Designated critical habitat for steelhead, coho, sockeye, and Pacific eulachon is not present in the Study Area and would not be impacted.

Pursuant to the ESA, the use of decelerators/parachutes during with training activities, as described under Alternative 2, may affect ESA-listed salmonid species, green sturgeon (Southern DPS), Pacific eulachon, bull trout (Coastal Puget Sound DPS), bocaccio rockfish (Puget Sound/Georgia Basin DPS) and yelloweye rockfish (Puget Sound/Georgia Basin DPS), and may affect critical habitat for Chinook (Puget Sound ESU), chum salmon (Hood Canal summer-run ESU), green sturgeon, bocaccio rockfish, and yelloweye rockfish. The Navy has consulted with NMFS and USFWS, as required by section 7(a)(2) of the ESA. The use of decelerators/parachutes would have no effect on critical habitat for bull trout.

Pursuant to the EFH requirements of the Magnuson-Stevens Fishery Conservation and Management Act and implementing regulations, the use of decelerators/parachutes associated with training activities, as described under Alternative 2, may affect EFH species within the Study Area.

Impacts from Decelerators/Parachutes Under Alternative 1 for Testing Activities

Under Alternative 1, the total number of decelerators/parachutes that would be expended during testing activities increases (1,181 to 1,887) compared to the number proposed for use in the 2015 NWTT Final EIS/OEIS. As shown in Table 3.0-20, the expenditure of small size decelerators/parachutes in the Offshore Area increases (1,068 to 1,711), and increases from 113 to 176 in the Inland Waters. No other sizes of decelerators/parachutes are proposed during testing activities. The activities that expend decelerators/parachutes would generally occur in the same locations and in a similar manner as were analyzed previously. Even though the number of decelerators/parachutes would increase during testing activities, the locations are similar to those analyzed in the 2015 NWTT Final EIS/OEIS, and impacts on fishes would be expected to be the same. As stated in the 2015 NWTT Final EIS/OEIS, the impact of decelerators/parachutes on fishes would be inconsequential for the same reasons presented above for wires and cables.

Designated critical habitat for steelhead, coho, sockeye, and Pacific eulachon is not present in the Study Area and would not be impacted.

Pursuant to the ESA, the use of decelerators/parachutes during testing activities, as described under Alternative 1, may affect ESA-listed salmonid species, green sturgeon (Southern DPS), Pacific eulachon, bull trout (Coastal Puget Sound DPS), bocaccio rockfish (Puget Sound/Georgia Basin DPS) and yelloweye rockfish (Puget Sound/Georgia Basin DPS), and may affect critical habitat for Chinook (Puget Sound ESU), chum salmon (Hood Canal summer-run ESU), green sturgeon, bocaccio rockfish, and yelloweye rockfish. The Navy has consulted with NMFS and USFWS, as required by section 7(a)(2) of the ESA. The use of decelerators/parachutes would have no effect on critical habitat for bull trout.

Pursuant to the EFH requirements of the Magnuson-Stevens Fishery Conservation and Management Act and implementing regulations, the use of decelerators/parachutes associated with testing activities, as described under Alternative 1, may affect EFH species within the Study Area.

3.9.3.5.2.2 Impacts from Decelerators/Parachutes Under Alternative 2

Impacts from Decelerators/Parachutes Under Alternative 2 for Training Activities

Under Alternative 2, the total number of decelerators/parachutes that would be expended during training activities increases compared to the number proposed for use under Alternative 1 (from 9,456 to 9,563) (Table 3.0-20) and in the 2015 NWTT Final EIS/OEIS (9,097 to 9,563). As shown in Table 3.0-20, the expenditure of small size decelerators/parachutes in the Offshore Area is proposed to increase (9,354 to 9,394), and no small decelerators/parachutes are proposed to be used in the Inland Waters, where none were proposed previously. The number of medium decelerators/parachutes in the Offshore Area increases from 4 to 24 compared to Alternative 1 and is the same as the 2015 NWTT Final EIS/OEIS. The number of large decelerators/parachutes in the Offshore Area increases from 98 to 145 (Table 3.0-20) compared to Alternative 1 and is the same as the 2015 NWTT Final EIS/OEIS. The activities that expend decelerators/parachutes would generally occur in the same locations and in a similar manner as were analyzed previously. Because the number and locations of these decelerators/parachutes is similar to those analyzed in the 2015 NWTT Final EIS/OEIS, the impacts on fishes would be expected to be the same. As stated in the 2015 NWTT Final EIS/OEIS, the impact of decelerators/parachutes on fishes would be inconsequential for the same reasons detailed above under Alternative 1.

Designated critical habitat for steelhead, coho, sockeye, and Pacific eulachon is not present in the Study Area and would not be impacted.

Pursuant to the ESA, the use of decelerators/parachutes during training activities, as described under Alternative 2, may affect ESA-listed salmonid species, green sturgeon (Southern DPS), Pacific eulachon, bull trout (Coastal Puget Sound DPS), bocaccio rockfish (Puget Sound/Georgia Basin DPS) and yelloweye rockfish (Puget Sound/Georgia Basin DPS), and may affect critical habitat for Chinook (Puget Sound ESU), chum salmon (Hood Canal summer-run ESU), green sturgeon, bocaccio rockfish, and yelloweye rockfish. The use of decelerators/parachutes would have no effect on critical habitat for bull trout.

Pursuant to the EFH requirements of the Magnuson-Stevens Fishery Conservation and Management Act and implementing regulations, the use of decelerators/parachutes associated with training activities, as described under Alternative 2, may affect EFH species within the Study Area.

Impacts from Decelerators/Parachutes Under Alternative 2 for Testing Activities

Under Alternative 2, the total number of decelerators/parachutes that would be expended during testing activities increases compared to the number proposed for use under Alternative 1 (from 1,887 to 1,895) (Table 3.0-20) and in the 2015 NWTT Final EIS/OEIS (1,181 to 1,991). As shown in Table 3.0-20, the expenditure of small decelerators/parachutes would be the same in the Offshore Area compared to Alternative 1 and increase compared to the 2015 NWTT Final EIS/OEIS (from 1,068 to 1,711). The expenditure of small decelerators/parachutes in Inland Waters would increase compared to both Alternative 1 (176to 184) and the previous analysis (113 to 232). The activities that expend decelerators/parachutes would generally occur in the same locations and in a similar manner as were analyzed previously. Even though the number of decelerators/parachutes would increase during testing activities, the locations are similar to those analyzed in the 2015 NWTT Final EIS/OEIS, and impacts on fishes would be expected to be the same. As stated in the 2015 NWTT Final EIS/OEIS, the impact of decelerators/parachutes on fishes would be inconsequential for the same reasons presented above for wires and cables.

Designated critical habitat for steelhead, coho, sockeye, and Pacific eulachon is not present in the Study Area and would not be impacted.

Pursuant to the ESA, the use of decelerators/parachutes during testing activities, as described under Alternative 2, may affect ESA-listed salmonid species, green sturgeon (Southern DPS), Pacific eulachon, bull trout (Coastal Puget Sound DPS), bocaccio rockfish (Puget Sound/Georgia Basin DPS) and yelloweye rockfish (Puget Sound/Georgia Basin DPS), and may affect critical habitat for Chinook (Puget Sound ESU), chum salmon (Hood Canal summer-run ESU), green sturgeon, bocaccio rockfish, and yelloweye rockfish. The use of decelerators/parachutes would have no effect on critical habitat for bull trout.

Pursuant to the EFH requirements of the Magnuson-Stevens Fishery Conservation and Management Act and implementing regulations, the use of decelerators/parachutes associated with testing activities, as described under Alternative 2, may affect EFH species within the Study Area.

3.9.3.5.2.3 Impacts from Decelerators/Parachutes Under the No Action Alternative

Under the No Action Alternative, proposed training and testing activities would not occur. Entanglement stressors as listed above would not be introduced into the marine environment. Therefore, existing environmental conditions would either remain unchanged or would improve slightly after cessation of ongoing training and testing activities.

Discontinuing the training and testing activities would result in fewer entanglement stressors within the marine environment where training and testing activities have historically been conducted. Therefore, discontinuing training and testing activities under the No Action Alternative would lessen the potential for entanglement impacts on individual fish, but would not measurably improve the status of fish populations or subpopulations.

3.9.3.5.3 Impacts from Biodegradable Polymer

Biodegradable polymers were not proposed for use in the 2015 NWTT Final EIS/OEIS, and for this Supplemental would be used only during proposed testing activities, not during training activities. For a discussion of where biodegradable polymers are used and how many activities would occur under each alternative, see Section 3.0.3.5.3 (Biodegradable Polymer). The biodegradable polymers that the Navy uses are designed to temporarily interact with the propeller(s) of a target craft, rendering it ineffective. A biodegradable polymer is a high molecular weight polymer that degrades to smaller compounds as a result of microorganisms and enzymes. The rate of biodegradation could vary from hours to years and the type of small molecules formed during degradation can range from complex to simple products, depending on whether the polymers are natural or synthetic (Karlsson & Albertsson, 1998). Based on the constituents of the biodegradable polymer the Navy proposes to use, it is anticipated that the material will break down into small pieces within a few days to weeks. This will break down further and dissolve into the water column within weeks to a few months. The final products which are all environmentally benign will be dispersed quickly to undetectable concentrations. Unlike other entanglement stressors, biodegradable polymers only retain their strength for a relatively short period of time, therefore the potential for entanglement by a fish would be limited. Furthermore, the longer the biodegradable polymer remains in the water, the weaker it becomes making it more brittle and likely to break. A fish would have to encounter the biodegradable polymer immediately after it was expended for it to be a potential entanglement risk. If a fish were to encounter the polymer a few hours after it was expended, it is very likely that it would break easily and would no longer be an entanglement stressor.

3.9.3.5.3.1 Impacts from Biodegradable Polymer Under Alternative 1

Impacts from Biodegradable Polymer Under Alternative 1 for Training Activities

No biodegradable polymers are proposed to be used for training activities under Alternative 1.

Impacts from Biodegradable Polymer Under Alternative 1 for Testing Activities

As shown in Table 3.0-21, four testing activities involving the use of biodegradable polymers are proposed to only be conducted in the Inland Waters under Alternative 1. The impact of biodegradable polymers on fish would be inconsequential because biodegradable polymers only retain their strength for a relatively short period of time and a fish would have to encounter the biodegradable polymer immediately after it was expended for it to be a potential entanglement risk.

Designated critical habitat for steelhead, coho, sockeye, and Pacific eulachon is not present in the Study Area and would not be impacted.

Pursuant to the ESA, the use of biodegradable polymers during testing activities, as described under Alternative 1, may affect ESA-listed salmonid species, green sturgeon (Southern DPS), Pacific eulachon, bull trout (Coastal Puget Sound DPS), bocaccio rockfish (Puget Sound/Georgia Basin DPS) and yelloweye rockfish (Puget Sound/Georgia Basin DPS), and may affect critical habitat for Chinook (Puget Sound ESU), chum salmon (Hood Canal summer-run ESU), green sturgeon, bull trout, bocaccio rockfish, and yelloweye rockfish. The Navy has consulted with NMFS and USFWS, as required by section 7(a)(2) of the ESA.

Pursuant to the EFH requirements of the Magnuson-Stevens Fishery Conservation and Management Act and implementing regulations, the use of biodegradable polymers associated with testing activities, as described under Alternative 1, may affect EFH species within the Study Area.

3.9.3.5.3.2 Impacts from Biodegradable Polymer Under Alternative 2

Impacts from Biodegradable Polymer Under Alternative 2 for Training Activities

No biodegradable polymers are proposed to be used for training activities under Alternative 2.

Impacts from Biodegradable Polymer Under Alternative 2 for Testing Activities

As shown in Table 3.0-21, four testing activities involving the use of biodegradable polymers are proposed to be conducted in the Inland Waters under Alternative 2, the same as Alternative 1. The impact of biodegradable polymers on fishes would be inconsequential because biodegradable polymers only retain their strength for a relatively short period of time and a fish would have to encounter the biodegradable polymer immediately after it was expended for it to be a potential entanglement risk. As detailed above and in the 2015 NWTT Final EIS/OEIS, fish are not particularly susceptible to entanglement stressors, including biodegradable polymers and would likely only be temporarily disturbed.

Designated critical habitat for steelhead, coho, sockeye, and Pacific eulachon is not present in the Study Area and would not be impacted.

Pursuant to the ESA, the use of biodegradable polymers during testing activities, as described under Alternative 2, may affect ESA-listed salmonid species, green sturgeon (Southern DPS), Pacific eulachon, bull trout (Coastal Puget Sound DPS), bocaccio rockfish (Puget Sound/Georgia Basin DPS) and yelloweye rockfish (Puget Sound/Georgia Basin DPS), and may affect critical habitat for Chinook (Puget Sound ESU), chum salmon (Hood Canal summer-run ESU), green sturgeon, bull trout, bocaccio rockfish, and yelloweye rockfish.

Pursuant to the EFH requirements of the Magnuson-Stevens Fishery Conservation and Management Act and implementing regulations, the use of biodegradable polymers associated with testing activities, as described under Alternative 2, may affect EFH species within the Study Area.

3.9.3.5.3.3 Impacts from Biodegradable Polymer Under the No Action Alternative

Under the No Action Alternative, proposed training and testing activities would not occur. Entanglement stressors as listed above would not be introduced into the marine environment. Therefore, existing environmental conditions would remain unchanged after cessation of ongoing training and testing activities.

Discontinuing the training and testing activities would result in fewer entanglement stressors within the marine environment where training and testing activities have historically been conducted. Therefore, discontinuing training and testing activities under the No Action Alternative would lessen the potential for entanglement impacts on individual fish, but would not measurably improve the status of fish populations or subpopulations.

3.9.3.6 Ingestion Stressors

The ingestions stressors that may impact fishes include military expended materials from munitions (non-explosive practice munitions and fragments from high-explosives) and military expended materials other than munitions (fragments from targets, chaff and flare components, decelerators/parachutes, and biodegradable polymers). Biodegradable polymer is a new stressor not previously analyzed, but the other stressors remain the same as analyzed in the 2015 NWTT Final EIS/OEIS.

3.9.3.6.1 Impacts from Military Expended Materials – Munitions

The military expends materials during training and testing in the Study Area that could become ingestion stressors, including non-explosive practice munitions (small- and medium-caliber), fragments from explosives, fragments from targets, chaff, flare casings (including plastic end caps and pistons), and small decelerators/parachutes. Metal items eaten by marine fish are generally small (such as fishhooks, bottle caps, and metal springs), suggesting that small- and medium-caliber projectiles, pistons, or end caps (from chaff canisters or flares) are more likely to be ingested. Both physical and toxicological impacts could occur as a result of consuming metal or plastic materials (Dantas et al., 2012; Davison & Asch, 2011; Possatto et al., 2011). Ingestion of plastics has been shown to increase hazardous chemicals in fish leading to liver toxicity of fishes (Rochman et al., 2013). Items of concern are those of ingestible size that either drift at or just below the surface (or in the water column) for a time or sink immediately to the seafloor. The likelihood that expended items would cause a potential impact on a given fish species depends on the size and feeding habits of the fish and the rate at which the fish encounters the item and the composition of the item. In this analysis only small- and medium-caliber munitions (or small fragments from larger munitions), chaff, small decelerators/parachutes, and end caps and pistons from flares and chaff cartridges are considered to be of ingestible size for a fish.

3.9.3.6.1.1 Impacts from Military Expended Materials – Munitions Under Alternative 1

Impacts from Military Expended Materials – Munitions Under Alternative 1 for Training Activities

Under Alternative 1, the number of military expended materials – munitions that would be used during training activities (Table 3.0-14 and Table 3.0-16) is generally consistent with the number proposed for use in the 2015 NWTT Final EIS/OEIS. When the amount of military expended materials from munitions are combined, the number of items proposed to be expended under Alternative 1 decreases from ongoing activities. The activities that expend military materials would occur in the same locations and in a similar manner as were analyzed previously. Therefore, the impacts on fishes would be expected to be the same. As stated in the 2015 NWTT Final EIS/OEIS, ingestion of military expended materials could result in sublethal or lethal effects to a small number of individuals, but the likelihood of a fish encountering an expended item is dependent on where that species feeds and the amount of material expended. Furthermore, as described in Section 3.1.4.1 (Explosives and Explosive Byproducts) and Table 3.1-7 in the 2015 NWTT Final EIS/OEIS, the majority of explosives byproducts from commonly used explosives materials that may be consumed (by fishes) are naturally occurring compounds in the marine environment. For example, 98 percent (by weight) of the explosives byproducts of royal demolition explosive (RDX) consistent of nitrogen, carbon dioxide, water, carbon monoxide, ammonia, and hydrogen. An encounter may not lead to ingestion, as a fish might "taste" an item and then expel it, in the same manner that a fish would take a lure into its mouth then spit it out, and would not consume toxic materials. Therefore, the number of fishes potentially impacted by ingestion of military expended materials such as munitions would be low and population-level effects are not expected.

Designated critical habitat for steelhead, coho, sockeye, and Pacific eulachon is not present in the Study Area and would not be impacted.

Pursuant to the ESA, the use of military expended materials – munitions of ingestible size during with training activities, as described under Alternative 1, may affect ESA-listed salmonid species, green sturgeon (Southern DPS), Pacific eulachon, bull trout (Coastal Puget Sound DPS), bocaccio rockfish (Puget Sound/Georgia Basin DPS), and yelloweye rockfish (Puget Sound/Georgia Basin DPS) and may affect critical habitat for Chinook (Puget Sound ESU), chum salmon (Hood Canal summer-run ESU), green sturgeon, bull trout, bocaccio rockfish and yelloweye rockfish. The Navy has consulted with NMFS and USFWS, as required by section 7(a)(2) of the ESA.

Pursuant to the EFH requirements of the Magnuson-Stevens Fishery Conservation and Management Act and implementing regulations, the use of military expended materials – munitions of ingestible size associated with training activities, as described under Alternative 1, may affect EFH species within the Study Area.

Impacts from Military Expended Materials – Munitions Under Alternative 1 for Testing Activities

Under Alternative 1, the number of military expended materials – munitions that would be used during testing activities (Table 3.0-14 and Table 3.0-16) is generally consistent with the number proposed for use in the 2015 NWTT Final EIS/OEIS. When the amount of military expended materials from munitions (non-explosive practice munitions and fragments from high explosives) are combined, the number of items proposed to be expended under Alternative 1 increases compared to ongoing activities. The activities that expend military materials would occur in the same locations and in a similar manner as were analyzed previously. Therefore, the impacts on fishes would be expected to be the same. As stated in the 2015 NWTT Final EIS/OEIS, ingestion of military expended materials could result in sublethal or lethal effects to a small number of individuals, but the likelihood of a fish encountering an expended item is dependent on where that species feeds and the amount of material expended. Furthermore, an encounter may not lead to ingestion, as a fish might "taste" an item and then expel it, in the same manner that a fish would take a lure into its mouth then spit it out. Therefore, the number of fishes potentially impacted by ingestion of military expended materials such as munitions would be low and population-level effects are not expected.

Designated critical habitat for steelhead, coho, sockeye, and Pacific eulachon is not present in the Study Area and would not be impacted.

Pursuant to the ESA, the use of military expended materials – munitions of ingestible size during testing activities, as described under Alternative 1, may affect ESA-listed salmonid species, green sturgeon (Southern DPS), Pacific eulachon, bull trout (Coastal Puget Sound DPS), bocaccio rockfish (Puget Sound/Georgia Basin DPS), and yelloweye rockfish (Puget Sound/Georgia Basin DPS) and may affect critical habitat for Chinook (Puget Sound ESU), chum salmon (Hood Canal summer-run ESU), green sturgeon, bull trout, bocaccio rockfish and yelloweye rockfish. The Navy has consulted with NMFS and USFWS, as required by section 7(a)(2) of the ESA.

Pursuant to the EFH requirements of the Magnuson-Stevens Fishery Conservation and Management Act and implementing regulations, the use of military expended materials – munitions of ingestible size associated with testing activities, as described under Alternative 1, may affect EFH species within the Study Area.

3.9.3.6.1.2 Impacts from Military Expended Materials – Munitions Under Alternative 2

Impacts from Military Expended Materials – Munitions Under Alternative 2 for Training Activities

Under Alternative 2, the number of military expended materials – munitions that would be used during training activities (Table 3.0-14 and Table 3.0-16) is generally consistent with the number proposed for use in the 2015 NWTT Final EIS/OEIS. When the amount of military expended materials from munitions are combined, the number of items proposed to be expended under Alternative 2 increases compared to both Alternative 1 (Table 3.0-14 and Table 3.0-16) and ongoing activities. The activities that expend military materials would occur in the same locations and in a similar manner as were analyzed previously. Therefore, the impacts on fishes would be expected to be the same. As stated in the 2015 NWTT Final EIS/OEIS, ingestion of military expended materials could result in sublethal or lethal effects to a small number of individuals, but the likelihood of a fish encountering an expended item is dependent on where that species feeds and the amount of material expended. Furthermore, an encounter may not lead to ingestion, as a fish might "taste" an item and then expel it, in the same manner that a fish would take a lure into its mouth then spit it out. Therefore, the number of fishes potentially impacted by ingestion of military expended materials such as munitions would be low and population-level effects are not expected.

Designated critical habitat for steelhead, coho, sockeye, and Pacific eulachon is not present in the Study Area and would not be impacted.

Pursuant to the ESA, the use of military expended materials – munitions of ingestible size during with training activities, as described under Alternative 2, may affect ESA-listed salmonid species, green sturgeon (Southern DPS), Pacific eulachon, bull trout (Coastal Puget Sound DPS), bocaccio rockfish (Puget Sound/Georgia Basin DPS), and yelloweye rockfish (Puget Sound/Georgia Basin DPS) and may affect critical habitat for Chinook (Puget Sound ESU), chum salmon (Hood Canal summer-run ESU), green sturgeon, bull trout, bocaccio rockfish and yelloweye rockfish.

Pursuant to the EFH requirements of the Magnuson-Stevens Fishery Conservation and Management Act and implementing regulations, the use of military expended materials – munitions of ingestible size associated with training activities, as described under Alternative 2, may affect EFH species within the Study Area.

Impacts from Military Expended Materials – Munitions Under Alternative 2 for Testing Activities

Under Alternative 2, the number of military expended materials – munitions that would be used during testing activities is generally consistent with the number proposed for use under Alternative 1 (Table 3.0-14 and Table 3.0-16) and greater than the numbers presented in in the 2015 NWTT Final EIS/OEIS. When the amount of military expended materials from munitions are combined, the number of items proposed to be expended under Alternative 2 decreases compared to ongoing activities. The activities that expend military materials would occur in the same locations and in a similar manner as were analyzed previously. Therefore, the impacts on fishes would be expected to be the same as stated in the 2015 NWTT Final EIS/OEIS, ingestion of military expended materials could result in sublethal or lethal effects to a small number of individuals, but the likelihood of a fish encountering an expended item is dependent on where that species feeds and the amount of material expended. Furthermore, an encounter may not lead to ingestion, as a fish might "taste" an item and then expel it, in the same manner that a fish would take a lure into its mouth then spit it out. Therefore, the number of fishes potentially impacted by ingestion of military expended materials such as munitions would be low and population-level effects are not expected.

Designated critical habitat for steelhead, coho, sockeye, and Pacific eulachon is not present in the Study Area and would not be impacted.

Pursuant to the ESA, the use of military expended materials – munitions of ingestible size during testing activities, as described under Alternative 2, may affect ESA-listed salmonid species, green sturgeon (Southern DPS), Pacific eulachon, bull trout (Coastal Puget Sound DPS), bocaccio rockfish (Puget Sound/Georgia Basin DPS), and yelloweye rockfish (Puget Sound/Georgia Basin DPS) and may affect critical habitat for Chinook (Puget Sound ESU), chum salmon (Hood Canal summer-run ESU), green sturgeon, bull trout, bocaccio rockfish and yelloweye rockfish.

Pursuant to the EFH requirements of the Magnuson-Stevens Fishery Conservation and Management Act and implementing regulations, the use of military expended materials – munitions of ingestible size associated with testing activities, as described under Alternative 2, may affect EFH species within the Study Area.

3.9.3.6.1.3 Impacts from Military Expended Materials – Munitions Under the No Action Alternative

Under the No Action Alternative, proposed training and testing activities would not occur. Ingestion stressors as listed above would not be introduced into the marine environment. Therefore, existing environmental conditions would either remain unchanged or would improve slightly after cessation of ongoing training and testing activities.

Discontinuing the training and testing activities would result in fewer ingestion stressors within the marine environment where training and testing activities have historically been conducted. Therefore, discontinuing training and testing activities under the No Action Alternative would lessen the potential for ingestion impacts on individual fish, but would not measurably improve the status of fish populations or subpopulations.

3.9.3.6.2 Impacts from Military Expended Materials – Other than Munitions

3.9.3.6.2.1 Impacts from Military Expended Materials – Other than Munitions Under Alternative 1

Impacts from Military Expended Materials – Other than Munitions Under Alternative 1 for Training Activities

Under Alternative 1, the number of military expended materials other than munitions that would be used during training activities (Table 3.0-17, Table 3.0-20, Table 3.0-21, and Table 3.0-22) is generally consistent with the number proposed for use in the 2015 NWTT Final EIS/OEIS. When the amount of military expended materials other than munitions (fragments from targets, chaff and flare components, and biodegradable polymers) are combined, the number of items proposed to be expended under Alternative 1 increases from ongoing activities. The activities that expend military materials would occur in the same locations and in a similar manner as were analyzed previously. Therefore, the impacts on fishes would be expected to be the same. As stated in the 2015 NWTT Final EIS/OEIS, ingestion of military expended materials other than munitions could result in sublethal or lethal effects to a small number of individuals, but the likelihood of a fish encountering an expended item is dependent on where that species feeds and the amount of material expended. Furthermore, an encounter may not lead to ingestion, as a fish might “taste” an item and then expel it, in the same manner that a fish would take a lure into its mouth then spit it out. Therefore, the number of fishes potentially impacted by ingestion of military expended materials such as munitions would be low and population-level effects are not expected.

Designated critical habitat for steelhead, coho, sockeye, and Pacific eulachon is not present in the Study Area and would not be impacted.

Pursuant to the ESA, the use of military expended materials other than munitions of ingestible size during with training activities, as described under Alternative 1, may affect ESA-listed salmonid species, green sturgeon (Southern DPS), Pacific eulachon, bull trout (Coastal Puget Sound DPS), bocaccio rockfish (Puget Sound/Georgia Basin DPS), and yelloweye rockfish (Puget Sound/Georgia Basin DPS) and may affect critical habitat for Chinook (Puget Sound ESU), chum salmon (Hood Canal summer-run ESU), green sturgeon, bull trout, bocaccio rockfish and yelloweye rockfish. The Navy has consulted with NMFS and USFWS, as required by section 7(a)(2) of the ESA.

Pursuant to the EFH requirements of the Magnuson-Stevens Fishery Conservation and Management Act and implementing regulations, the use of military expended materials other than munitions of ingestible size associated with training activities, as described under Alternative 1, may affect EFH species within the Study Area.

Impacts from Military Expended Materials – Other than Munitions Under Alternative 1 for Testing Activities

Under Alternative 1, the number of military expended materials other than munitions that would be used during testing activities (Table 3.0-17, Table 3.0-20, Table 3.0-21, and Table 3.0-22) decreases compared to the number proposed for use in the 2015 NWTT Final EIS/OEIS. Other than the addition of biodegradable polymer, which would occur four times annually in the Inland Waters, the activities that expend military materials would occur in the same locations and in a similar manner as were analyzed previously. Based on the constituents of the biodegradable polymer the Navy proposes to use, it is anticipated that the material will breakdown into small pieces within a few days to weeks, eventually dissolving into the water column as environmentally benign products. Being benign, if ingested, the remnants of the biodegradable polymer would pose limited risk to fishes. Even though there would be a substantial increase in the number of military expended materials other than munitions and as stated in the 2015 NWTT Final EIS/OEIS, ingestion of military expended materials other than munitions could result in sublethal or lethal effects to a small number of individuals, but the likelihood of a fish encountering an expended item is dependent on where that species feeds and the amount of material expended. Furthermore, an encounter may not lead to ingestion, as a fish might "taste" an item and then expel it, in the same manner that a fish would take a lure into its mouth then spit it out. Therefore, the number of fishes potentially impacted by ingestion of military expended materials such as munitions would be low and population-level effects are not expected.

Designated critical habitat for steelhead, coho, sockeye, and Pacific eulachon is not present in the Study Area and would not be impacted.

Pursuant to the ESA, the use of military expended materials other than munitions of ingestible size during testing activities, as described under Alternative 1, may affect ESA-listed salmonid species, green sturgeon (Southern DPS), Pacific eulachon, bull trout (Coastal Puget Sound DPS), bocaccio rockfish (Puget Sound/Georgia Basin DPS), and yelloweye rockfish (Puget Sound/Georgia Basin DPS), and may affect critical habitat for Chinook (Puget Sound ESU), chum salmon (Hood Canal summer-run ESU), green sturgeon, bull trout, bocaccio rockfish and yelloweye rockfish. The Navy has consulted with NMFS and USFWS, as required by section 7(a)(2) of the ESA.

Pursuant to the EFH requirements of the Magnuson-Stevens Fishery Conservation and Management Act and implementing regulations, the use of military expended materials other than munitions of ingestible size associated with testing activities, as described under Alternative 1, may affect EFH species within the Study Area.

3.9.3.6.2.2 Impacts from Military Expended Materials – Other than Munitions Under Alternative 2

Impacts from Military Expended Materials – Other than Munitions Under Alternative 2 for Training Activities

Under Alternative 2, the number of military expended materials other than munitions that would be used during training activities is generally consistent with the number proposed for use under Alternative 1 (Table 3.0-17, Table 3.0-20, Table 3.0-21, and Table 3.0-22) and in the 2015 NWTT Final EIS/OEIS. When the amount of military expended materials other than munitions (fragments from targets, chaff and flare components, and biodegradable polymers) are combined, the number of items proposed to be expended under Alternative 2 increases slightly compared to Alternative 1 and increases compared to ongoing activities. The activities that expend military materials would occur in the same locations and in a similar manner as were analyzed previously. Therefore, the impacts on fishes would be expected to be the same. As stated in the 2015 NWTT Final EIS/OEIS and above under Alternative 1, ingestion of military expended materials other than munitions could result in sublethal or lethal effects to a small number of individuals, but the likelihood of a fish encountering an expended item is dependent on where that species feeds and the amount of material expended. Furthermore, an encounter may not lead to ingestion, as a fish might "taste" an item and then expel it, in the same manner that a fish would take a lure into its mouth then spit it out. Therefore, the number of fishes potentially impacted by ingestion of military expended materials such as munitions would be low and population-level effects are not expected.

Designated critical habitat for steelhead, coho, sockeye, and Pacific eulachon is not present in the Study Area and would not be impacted.

Pursuant to the ESA, the use of military expended materials other than munitions of ingestible size during with training activities, as described under Alternative 2, may affect ESA-listed salmonid species, green sturgeon (Southern DPS), Pacific eulachon, bull trout (Coastal Puget Sound DPS), bocaccio rockfish (Puget Sound/Georgia Basin DPS), and yelloweye rockfish (Puget Sound/Georgia Basin DPS) and may affect critical habitat for Chinook (Puget Sound ESU), chum salmon (Hood Canal summer-run ESU), green sturgeon, bull trout, bocaccio rockfish and yelloweye rockfish.

Pursuant to the EFH requirements of the Magnuson-Stevens Fishery Conservation and Management Act and implementing regulations, the use of military expended materials other than munitions of ingestible size associated with training activities, as described under Alternative 2, may affect EFH species within the Study Area.

Impacts from Military Expended Materials – Other than Munitions Under Alternative 2 for Testing Activities

Under Alternative 2, the number of military expended materials other than munitions that would be used during testing activities is increased compared to the number proposed for use under Alternative 1 (Table 3.0-17, Table 3.0-20, Table 3.0-21, and Table 3.0-22) and decreases slightly from ongoing activities. Other than the addition of biodegradable polymer, which would occur four times annually in the Inland Waters, the activities that expend military materials would occur in the same locations and in a similar manner as were analyzed previously. Based on the constituents of the biodegradable polymer the Navy proposes to use, it is anticipated that the material will breakdown into small pieces within a few days to weeks, eventually dissolving into the water column as environmentally benign products. Being benign, if ingested, the remnants of the biodegradable polymer would pose limited risk to fishes. Even though there would be a substantial increase in the number of military expended materials other than munitions and as stated in the 2015 NWTT Final EIS/OEIS and above under Alternative 1, ingestion of military expended materials other than munitions could result in sublethal or lethal effects to a small number of individuals, but the likelihood of a fish encountering an expended item is dependent on where that species feeds and the amount of material expended. Furthermore, an encounter may not lead to ingestion, as a fish might “taste” an item and then expel it, in the same manner that a fish would take a lure into its mouth then spit it out. Therefore, the number of fishes potentially impacted by ingestion of military expended materials such as munitions would be low and population-level effects are not expected.

Designated critical habitat for steelhead, coho, sockeye, and Pacific eulachon is not present in the Study Area and would not be impacted.

Pursuant to the ESA, the use of military expended materials other than munitions of ingestible size during testing activities, as described under Alternative 2, may affect ESA-listed salmonid species, green sturgeon (Southern DPS), Pacific eulachon, bull trout (Coastal Puget Sound DPS), bocaccio rockfish (Puget Sound/Georgia Basin DPS), and yelloweye rockfish (Puget Sound/Georgia Basin DPS) and may affect critical habitat for Chinook (Puget Sound ESU), chum salmon (Hood Canal summer-run ESU), green sturgeon, bull trout, bocaccio rockfish and yelloweye rockfish.

Pursuant to the EFH requirements of the Magnuson-Stevens Fishery Conservation and Management Act and implementing regulations, the use of military expended materials other than munitions of ingestible size associated with testing activities, as described under Alternative 2, may affect EFH species within the Study Area.

3.9.3.6.2.3 Impacts from Military Expended Materials – Other than Munitions Under the No Action Alternative

Under the No Action Alternative, proposed training and testing activities would not occur. Ingestion stressors as listed above would not be introduced into the marine environment. Therefore, existing environmental conditions would either remain unchanged or would improve slightly after cessation of ongoing training and testing activities.

Discontinuing the training and testing activities would result in fewer ingestion stressors within the marine environment where training and testing activities have historically been conducted. Therefore, discontinuing training and testing activities under the No Action Alternative would lessen the potential for ingestion impacts on individual fish, but would not measurably improve the status of fish populations or subpopulations.

3.9.3.7 Secondary Stressors

Stressors from training and testing activities could pose secondary or indirect impacts on fishes via habitat, sediment, and water quality. These include (1) explosives and byproducts; (2) metals; (3) chemicals; (4) other materials such as targets, chaff, and plastics; and (5) impacts on fish habitat.

While the number of training and testing activities would change under this supplement, the analysis presented in the 2015 NWTT Final EIS/OEIS, Section 3.9.3.6 (Secondary Stressors) remains valid. The changes in training and testing activities are not substantial and would not result in an overall change to existing environmental conditions or an increase in the level or intensity of secondary stressors within the Study Area.

As stated in the 2015 NWTT Final EIS/OEIS, indirect impacts of explosives and unexploded ordnance on marine fishes via water could not only cause physical impacts, but prey might also have behavioral reactions to underwater sound. For example, the sound from underwater explosions might induce startle reactions and temporary dispersal of schooling fishes if they are within close proximity. The abundances of fish and invertebrate prey species near the detonation point could be diminished for a short period of time before being repopulated by animals from adjacent waters. Secondary impacts from underwater explosions would be temporary, and no lasting impact on prey availability or the pelagic food web would be expected. Indirect impacts of underwater detonations and explosive ordnance use under the proposed action would not result in a decrease in the quantity or quality of fish populations or fish habitats in the Study Area.

Indirect impacts of explosives and unexploded ordnance to fishes via sediment is possible in the immediate vicinity of the ordnance. Degradation of explosives proceeds via several pathways is discussed in Section 3.1 (Sediments and Water Quality). Degradation products of Royal Demolition Explosive are not toxic to marine organisms at realistic exposure levels (Rosen & Lotufo, 2010). TNT and its degradation products impact developmental processes in fishes and are acutely toxic to adults at concentrations similar to real-world exposures (Halpern et al., 2008; Rosen & Lotufo, 2010). It is likely that various lifestages of fishes could be impacted by the indirect impacts of degrading explosives within a very small radius of the explosive (1–6 ft.), but these impacts are expected to be short term and localized.

Certain metals are harmful to fishes at concentrations above background levels (e.g., cadmium, chromium, lead, mercury, zinc, copper, manganese, and many others) (Wang & Rainbow, 2008). Metals are introduced into seawater and sediments as a result of Navy training and testing activities involving vessel hulks, targets, ordnance, munitions, and other military expended materials. Indirect impacts of metals to fishes via water involve concentrations that are several orders of magnitude lower than concentrations achieved via bioaccumulation in the sediments. Fishes may be exposed by contact with the metal, contact with contaminants in the sediment or water, and ingestion of contaminated sediments. Concentrations of metals in seawater are orders of magnitude lower than concentrations in marine sediments. It is extremely unlikely that fishes would be indirectly impacted by toxic metals via the water.

Several military training and testing activities introduce potentially harmful chemicals into the marine environment; principally, flares and propellants for rockets, missiles, and torpedoes. The greatest risk to fishes from flares, missile, and rocket propellants is perchlorate, which is highly soluble in water, persistent, and impacts metabolic processes in many plants and animals. Fishes may be exposed by contact with contaminated water or ingestion of contaminated sediments. Since perchlorate is highly soluble, it does not readily absorb to sediments. Therefore, missile and rocket fuel poses no risk of indirect impact on fishes via sediment. In contrast, propylene glycol dinitrate and nitrodiphenylamine, the principal toxic components of torpedo fuel (OTTO Fuel II), adsorb to sediments, have relatively low toxicity, and are readily degraded by biological processes (Sun et al., 1996; U.S. Department of the Navy, 1996a, 1996b; Walker & Kaplan, 1992). It is conceivable that various lifestages of fishes could be indirectly impacted by propellants via sediment in the immediate vicinity of the object (e.g., within a few inches), but these potential impacts would diminish rapidly as the propellant degrades.

As described in the 2015 NWTT Final EIS/OEIS, some military expended materials (e.g., decelerators/parachutes) could become remobilized after their initial contact with the sea floor (e.g., by waves or currents) and could be reintroduced as an entanglement or ingestion hazard for fishes. In some bottom types (without strong currents, hard-packed sediments, and low biological productivity), items such as projectiles might remain intact for some time before becoming degraded or broken down by natural processes. While these items remain intact sitting on the bottom, they could potentially remain ingestion hazards. These potential impacts may cease only (1) when the military expended materials are too massive to be mobilized by typical oceanographic processes, (2) if the military expended materials become encrusted by natural processes and incorporated into the seafloor, or (3) when the military expended materials become permanently buried. In this scenario, a parachute could initially sink to the seafloor, but then be transported laterally through the water column or along the seafloor, increasing the opportunity for entanglement. In the unlikely event that a fish would become entangled, injury or mortality could result. The entanglement stressor would eventually cease to pose an entanglement risk as it becomes encrusted or buried, or degrades.

Secondary stressors can also involve impacts on habitat (sediment or water quality) or prey (i.e., impacting the availability or quality of prey) that have the potential to affect fish species. Secondary stressors that may affect ESA-listed species only include those related to the use of explosives. Secondary effects on prey and habitat from the release of metals, chemicals, and other materials into the marine environment during training and testing activities are not anticipated. In addition to directly impacting ESA-listed species, underwater explosives could impact other species in the food web, including those that these species prey upon. The impacts of explosions would differ depending upon the type of prey species in the area of the blast. In addition to physical effects of an underwater blast, prey might have behavioral reactions to underwater sound. For instance, prey species might exhibit a strong startle reaction to explosions that might include swimming to the surface or scattering away from the source. This startle and flight response is the most common secondary defense among animals. The abundances of prey species near the detonation point could be diminished for a short period of time, affecting prey availability for ESA-listed species feeding in the vicinity. Any effects to prey, other than those located within the impact zone when the explosive detonates, would be temporary. Direct impacts on fishes by affecting the availability or quality of prey is low and would not be expected.

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