

3.7 FISH

This section discusses the affected environment and environmental consequences that would result under each alternative for fish in the action area.

3.7.1 Affected Environment

This section provides an overview of fish in the action area, and specifically addresses fish of ecological or economic concern. The action area includes both marine fish in the U.S. EEZ and freshwater fish in the Great Lakes and rivers. These include fish species that are listed under the ESA, are associated with designated EFH (see Section 3.9 for a complete discussion of EFH), or are considered the basis of important fisheries. These fish are further addressed and discussed relative to their sensitivity to sound associated with proposed activities. The following sections provide descriptions of the fish, their hearing ability and sensitivity to sound, threatened and endangered designations, and regional distributions of fish and critical habitat.

Globally, there are over 30,000 species of fish, existing in marine (salt water) and freshwater environments. Some fish are diadromous species that spend a portion of their life cycle in both fresh water and salt water. Anadromous fish, a subset of diadromous species, hatch in fresh water, spend most of their lives in the salt water of the ocean, and then return to fresh water to spawn (e.g., salmon, smelt, shad, striped bass, and sturgeon). Catadromous fish, another subset of diadromous species, do the opposite; they live in fresh water and enter salt water to spawn (e.g., eels). Marine and freshwater fish are discussed separately, but the discussion of hearing ability and sensitivity to sound applies to all fish.

3.7.1.1 Marine Fish

Marine fish that live in the ocean consist of:

- Coastal fish that inhabit the sea between the shoreline and the edge of the continental shelf;
- Deep sea fish that live below the photic zone of the ocean, i.e., where not enough light penetrates for photosynthesis to occur;
- Pelagic fish that live near the surface of the ocean;
- Demersal fish that live on or near the bottom of the ocean; and
- Coral reef fish that are associated with coral reefs.

Marine fish occupy a wide variety of water depths and habitats. The vast majority of marine fishes are free-swimming pelagic forms. Other diverse and sometimes abundant fish species inhabit near-bottom and demersal (bottom) habitats (**Figure 3.7-1**), including flatfishes (Order Pleuronectiformes including soles, halibuts, and allies); sharks, skates, and rays; hagfishes; sturgeons; cods; rat-tails; and many others (Nelson, 2016). In general, sturgeons (Order Acipenseriformes), the herring-like fishes (Order Clupeiformes), and the cod-like fishes (Order Gadiformes) tend to occur only within the confines of the continental shelf. Other higher groups of fish are more widely dispersed. Some are highly migratory (e.g., tunas, lampreys, herrings, salmons) while others show high site fidelity (e.g., lingcod, some rockfishes, tropical reef fishes) (NSF and USGS, 2011). **Figure 3.7-2** depicts these ecological diversities among the higher groups of fish.



Figure 3.7-1. Demersal Flatfishes

Photo Credit: BreakingTheWalls

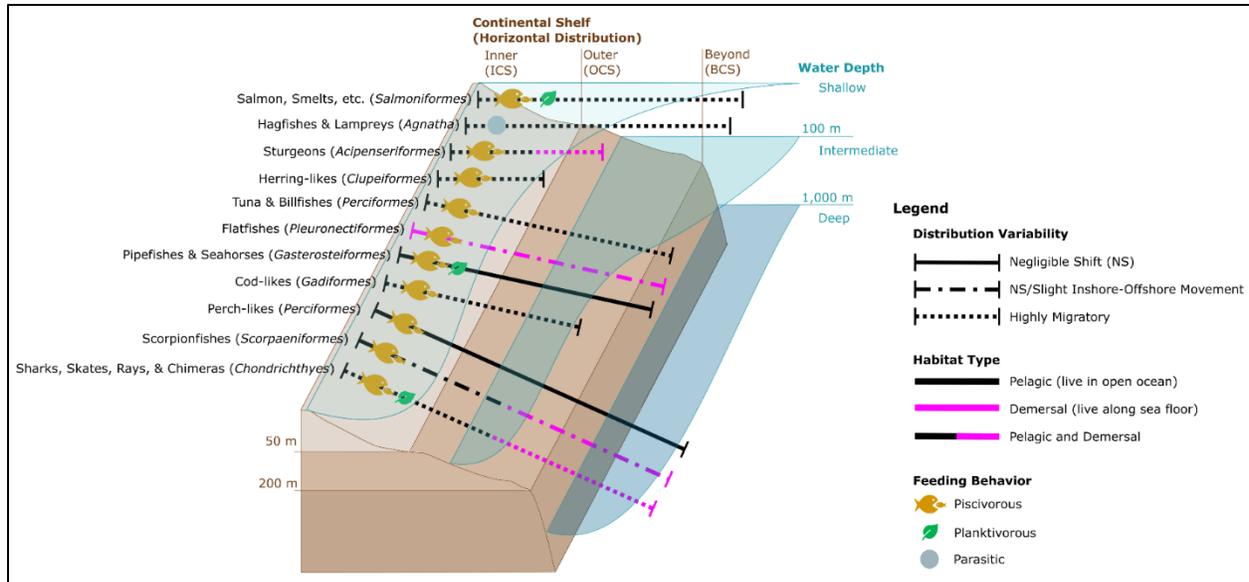
Most marine fish are piscivorous, meaning they primarily eat other fish. A few, such as anchovies, whale sharks, and basking sharks, are predominantly or exclusively planktivorous, consuming primarily small invertebrates (e.g., krill, zooplankton). Relatively few are primarily dependent on phytoplankton or macroalgae (e.g., seaweed like kelp) as food for much of their life cycle (NSF and USGS, 2011).

One system for classifying marine fish involves categorizing them into 11 main higher taxonomic groups (Sea Around Us, No Date). This classification system revolves around commercial species, but excludes many species of fish that are not commercial and might not fall into any of these higher groups. Therefore, marine fish can also be organized into groups based on ecology and habitat preferences. Taxa with special status (i.e., listed under ESA) occur within five of the higher groups: two Perciformes, eight Salmoniformes, two Scorpaeniformes, four Chondrichthyes, and three Acipenseriformes (see **Table 3.7-1**). The taxonomic groups, general ecology (i.e., habitat and feeding behavior), and general distribution and migratory movements of the marine fish in the action area are summarized in **Figure 3.7-2** and discussed briefly below.

Fish species distributions vary relative to major environmental factors such as water depth, salinity, temperature, and habitat type; but when viewed on a broad scale, they collectively segregate into recognizable multi-species assemblages. Many species overlap to some degree in these ecological groups, due in part to the different habitat areas used by different life stages (NMFS, 2016a). Based on general ecology and the three-dimensional occurrence of marine fish in the sea, fish can be grouped into the following assemblages: nearshore-demersal, nearshore-pelagic, oceanic-demersal, and oceanic-pelagic. An additional assemblage unique to polar regions is the cryopelagic fish assemblage. The term cryopelagic is used to describe fish that actively swim in nearshore or oceanic waters but are associated during their life cycle with ice or water immediately below the ice (NMFS, 2016a). An example is the Arctic cod which often occurs in ice holes, near the ice edge, or among broken ice.

Demersal resources include hard bottom fishes and soft bottom fishes. Hard bottom generally refers to exposed rock but includes other substrata such as coral and artificial structures. Hard bottom features provide structurally complex shelter, feeding opportunities, and hydrodynamic benefits for permanent and temporary fish associates (BOEM, 2014a). Hard bottom supports assemblages of sessile (non-mobile) organisms including algae, sponges, octocorals, and stony corals. Common families of hard bottom associated fishes are moray eels (Muraenidae), squirrelfishes (Holocentridae), groupers and sea basses

(Serranidae), scorpionfishes (Scorpaenidae), grunts (Haemulidae), snappers (Lutjanidae), porgies (Sparidae), wrasses (Labridae), damselfishes (Pomacentridae), angelfishes (Pomacanthidae), blennies (Labrisomidae and Blenniidae), and triggerfishes (Balistidae). Individual species from these families exhibit differential distributions across the continental shelf (or shelf), generally depending on water depth.



Sources: NMFS, No Date-a; Sea Around Us, No Date; ECOS, No Date-a

Notes:

Typical water depth: S = shallow (<100 m), I = intermediate (100-1,000 m), D = deep (>1,000 m).

Habitat Type: D = demersal; P = pelagic.

Feeding behavior: PV = piscivorous, PN = planktivorous, PS = parasitic, S = scavenger.

Horizontal Distribution: ICS = inner continental shelf (<50 m water depth), OCS = outer continental shelf (50-200 m), BCS = beyond continental shelf (>200 m).

Distribution Variability: NS = negligible shift, IO = slight inshore-offshore movement, HM = highly migratory.

Figure 3.7-2. Summary of the Status, General Ecology, and General Distribution and Movement of Marine Fish Groups Potentially Occurring within the Action Area

Soft bottom or sedimentary habitat is composed of medium to coarse carbonate sands distributed over an extensive continental shelf (BOEM, 2014a). Soft bottom is not always flat or featureless but forms structures at various spatial scales, including large shoals, medium sand waves, smaller sand ripples, and interstitial space among sediment grains. The presence and form of these features vary with distance from shore, latitude, water depth, proximity to river discharge, prevailing currents, and wave energy. Families of soft bottom demersal fishes include skates (Rajidae), rays (Dasyatidae, Myliobatidae, and Gymnuridae), snake eels (Ophichthidae), searobins (Triglidae), drums and croakers (Sciaenidae), lizardfishes (Synodontidae), sand flounders (Paralichthyidae), and tonguefishes (Cynoglossidae). Members of these families, as well as others, are distributed widely across the continental shelf and upper slope (the outer shelf), and individual species are represented in different depth-related assemblages.

Although nearshore-pelagic species associate with structured bottom, they respond primarily to water column structure (temperature, salinity, DO) and circulation (currents, eddies, fronts), which vary seasonally and spatially (BOEM, 2014a). Large-scale influences on water column structure and circulation also vary across the shelf. Inner shelf waters are driven primarily by river discharge, winds, and tidal action.

Intermediate shelf waters are mostly wind driven, whereas shelf-edge and upper slope waters are influenced primarily by actions such as the Gulf Stream. Coastal pelagic fishes include requiem sharks (Carcharhinidae), dogfish sharks (Squalidae), anchovies (Engraulidae), herrings (Clupeidae), mackerels (Scombridae), jacks (Carangidae), mullets (Mugilidae), bluefish (Pomatomidae), and cobia (Rachycentridae). Coastal pelagic species traverse shelf waters throughout the year, and many migrate during particular seasons.

The oceanic-pelagic assemblage consists of epipelagic and mesopelagic fish. Epipelagic fishes inhabit the upper 200 m (656 ft) of the water column in oceanic waters beyond the continental shelf edge (BOEM, 2014a). Families of epipelagic fishes include sharks (Lamnidae and Sphyrnidae), flyingfishes (Exocoetidae), halfbeaks (Hemiramphidae), oarfishes (Regalecidae and Lophotidae), snake mackerels (Gempylidae), jacks (Carangidae), dolphin (Coryphaenidae), pomfrets (Bramidae), marlins, sailfish and spearfish (Istiophoridae), swordfish (Xiphiidae), tunas (Scombridae), medusafishes (Centrolophidae), molas (Molidae), and triggerfishes (Balistidae). A number of these species, such as mahi-mahi (*Coryphaena hippurus*), sailfish (*Istiophorus platypterus*), white marlin (*Kajikia albida*), blue marlin (*Makaira nigricans*), and tunas (**Figure 3.7-3**), are important to commercial and recreational fisheries. Below the epipelagic zone, the water column may be layered into mesopelagic (200-1,000 m [656-3,280 ft]) and bathypelagic (>1,000 m [3,280 ft]) zones. Taken together, these two zones and their inhabitants may be referred to as midwater. In the mesopelagic zone, fish assemblages are numerically dominated by lanternfishes (Myctophidae), bristlemouths (Gonostomatidae), and hatchetfishes (Sternoptychidae). Mesopelagic fishes, while less commonly known, are ecologically important because they transfer significant amounts of energy between mesopelagic and epipelagic zones over each daily cycle. Lanternfishes are important prey for meso- and epipelagic predators (e.g., tunas), upper slope hard bottom fishes, and particularly the mesopelagic dragonfishes (Stomiiformes). The bathypelagic group is composed of little-known species such as snipe eels (Nemichthyidae), slimeheads (Trachichthyidae), deep-sea anglers (Melanocetidae), bigscales (Melamphaidae), and whalefishes (Cetomimidae). Most bathypelagic species are capable of producing and emitting light (bioluminescence) to aid in communicating in an environment devoid of sunlight (BOEM, 2014a).

Figure 3.7-3. Pelagic Atlantic Tunas



Photo Credit: Jeff Muir @ISSF

Important ecological considerations for fish resources of concern with respect to NOS activities are life-history and reproductive characteristics. These are important determinants of population-scale

vulnerability or robustness to disturbance. However, the reproductive strategies of marine fishes vary greatly, including those that bear live young, those that disperse their young as larvae, those that fertilize externally and broadcast their eggs, those that spawn into bottom-attached egg masses, or the nests (redds) of river spawners. More fecund fishes that have large ranges and high rates of dispersal tend to be more resilient to exploitation, disturbance, or other population-level stressors than those that are restricted to smaller areas and specific microhabitats.

In terms of commercial value, the herring-like fishes (e.g., herrings, sardines, shads, and anchovies) and cod-like fishes (e.g., cods, haddocks, hakes, pollocks, and whittings) are the most economically important. Next are perch-like fishes (the most modern, diverse, and speciose order, the Perciformes). The salmon and smelts (Order Salmoniformes) are also of great commercial importance.

The U.S. Geological Survey Nonindigenous Aquatic Species database tracks distributions of non-native marine fish, as well as other introduced aquatic species (USGS, No Date). One species that has become established along the southeast coast of the U.S., the Caribbean, and in parts of the Gulf of Mexico at unprecedented and alarming speed is the Indo-Pacific lionfish (*Pterois volitans* and *P. miles*) which is native to the tropical and subtropical areas of the southwest Pacific and Indian Oceans.

3.7.1.2 Freshwater Fish

Nearly half of all fish species live in fresh water. Freshwater fish spend some or all of their lives in fresh water, such as rivers and lakes, with a salinity of less than 1.05 percent. These environments differ from marine conditions in many ways, the most obvious being the difference in levels of salinity. Freshwater fish are generally separated into one of three different categories (warmwater, coldwater, or coolwater) based on water temperature and the associated amount of oxygen in the water at each temperature range. For example, cold water holds more oxygen than warm water, which means coldwater fish require higher oxygen levels in order to survive.

Warmwater fish species, such as largemouth bass (*Micropterus salmoides*), bluegill, catfish, crappies, and sunfish, can live in a wide range of conditions. Although they can survive cold winters in the northern states and can be found throughout most of the U.S., warmwater species thrive best when water temperatures are around 26°C (80°F). Coldwater fish live in water cold enough throughout the year to support species such as brook and rainbow trout, Atlantic salmon, slimy sculpin, blacknose and longnose dace, white suckers, and the non-native brown trout. Coldwater lakes and rivers generally occur in northern states with a temperature range of 4-15°C (40-60°F). Muskellunge, northern pike, walleye, and yellow perch are common coolwater fish species. These types of freshwater fish prefer water temperatures in-between the other two categories. Because these species grow best in water temperatures that range in the 15-21°C (60-70°F), they are most often found in the northern and midwestern states.

More than 150 native fish species occur in the Great Lakes. There are three major thermal groupings for fish communities in the Great Lakes based on their preferred summer temperature preference: warmwater (e.g., shad [Clupeidae family], catfishes [Ictaluridae family], basses and sunfishes [Centrarchidae family], and drum [Sciaenidae family]); coolwater (e.g., yellow perch [*Perca flavescens*], walleye [*Sander vitreus*], sturgeon [Acipenseriformes], and pikes [*Esox* spp.]); and coldwater (e.g., trout and salmon [Salmonidae family], whitefishes [*Coregonus* spp.], and deepwater sculpin [*Myoxocephalus thompsonii*]) (USACE, 2019).

Given these temperature tolerances, fish species diversity, composition, and productivity differ to various degrees among the five Great Lakes, in part because of the latitudinal temperature gradient from Lake Superior to Lake Erie. In Lake Erie, warm-water species like walleye are common, while salmonids predominate in the rest of the four cooler lakes. Within the lakes, abundance and diversity are generally highest in nearshore habitats because of the higher plankton productivity and complex habitat structure. Year-round species in nearshore waters are typically warm- or cool-water species, although nearshore waters are used seasonally for spawning by fish that primarily inhabit cold, deep water (USACE, 2019). Examples of deepwater species using nearshore waters for spawning are lake trout (*Salvelinus namaycush*), lake whitefish (*Coregonus clupeaformis*), burbot (*Lota lota*), and sculpins (Corridae family). Commercially and recreationally important species can be found in all the lake habitats. Economically valuable native fishes in the Great Lakes include smallmouth bass (*Micropterus dolomieu*), largemouth bass (*M. salmoides*), yellow perch, whitefish, and walleye. Nonnative species, like the Pacific salmonids (*Oncorhynchus* spp.), brown trout (*Salmo trutta*), and rainbow trout (*Oncorhynchus mykiss*) are also economically important.

Non-native fish species in the Great Lakes include common carp (*Cyprinus carpio*), alewife (*Alosa pseudoharengus*), sea lamprey (*Petromyzon marinus*) (Figure 3.7-4), round goby (*Neogobius melanostomus*), and rainbow smelt (*Osmerus mordax*) (USACE, 2019). There has also been intentional introduction of nonnative Pacific salmon into the Great Lakes including coho salmon (*Oncorhynchus kisutch*) and Chinook salmon (*O. tshawytscha*) (USACE, 2019).



Figure 3.7-4. Sea Lamprey

Photo Credit: Ted Lawrence/Great Lakes Fishery Commission

3.7.1.3 Sound Production and Hearing

Sound plays a major role in the lives of all fish (e.g., Zelick et al., 1999; Fay and Popper, 2000). This is particularly the case since sound travels much farther in water than other potential signals and is not impeded by darkness, currents, or obstacles in the environment. Thus, fish can glean a great deal of information about biotic (living) and abiotic (environmental) sources and get information about the environment at a very substantial distance from the source (e.g., the presence of a reef, or the sounds produced by swimming predators). Many species of bony fishes communicate with sounds and use sounds in a wide range of behaviors including mating and territorial interactions (BOEM, 2014a).

Hearing has been studied in only a few of the >30,000 species of fish. While fish may vary in their ability to detect and use sound and vary in their potential susceptibility to damage by sound, it is evident that there are common mechanisms of fish hearing (Popper et al., 2003).

Sound is detected by fish with their inner ear, which in many ways is similar to the vestibular apparatus of mammals. Fish do not have external openings to the ear and sound is not coupled to the ear as it is with terrestrial animals. Because fish have a similar acoustic impedance as the water, they move with the water in a passing sound wave (Yan, 2004). The otoliths of fish otolithic end organs (their inner ears) are denser than water and consequently move less during an acoustic disturbance than the fish as a whole. It is this relative motion of the otolith and the rest of the fish that all fish are able to sense as sound (Fay, 1988), and this mechanism of hearing means that fish naturally sense the particle motion aspect of sound as opposed to the pressure aspect that terrestrial animals sense. Pressure and particle motion are part of any sound wave, and some fish have specialized adaptations that allow them to additionally sense the pressure aspect of sound. Fish that are additionally sensitive to pressure use a gas-filled internal cavity near the ears, such as the swim bladder, that deforms with the pressure wave. The deformation of the gas bubble relays pressure information to the ears either because of its close proximity to the ears or because of direct mechanical coupling to the ears (e.g., Weberian ossicles).

The hearing frequency range of most fish is below approximately 1,500 Hz with the most sensitive range below 800 Hz. The hearing range of pressure-sensing fish is typically extended to a few kHz (up to about 4 kHz). It should be noted, however, that at least three species of herring-like fishes detect sounds above 20 kHz (ultrasound). This does not apply for the Atlantic herring (*Clupea harengus*) (Mann et al., 1997). These fish are thought to have evolved high-frequency sound detection in response to dolphin predation, but the mechanism for sensing the sound is not well understood.

Fishes can be categorized acoustically depending on how they might be affected by sounds based on the presence or absence of a swim bladder and on the potential for that swim bladder to improve the hearing sensitivity and range of hearing (Popper et al., 2014; BOEM, 2014a):

- Fishes with no swim bladder or other gas chamber. These species are less susceptible to barotrauma (injury from excessive water pressure) and only detect particle motion, not sound pressure. However, some barotrauma may result from exposure to sound pressure. The highest frequency of hearing is likely to be no greater than 400 Hz, with poor sensitivity compared to fishes with a swim bladder. Fishes within this group include flatfish, some gobies, some tunas, and all sharks and rays (and relatives).
- Fishes with swim bladders in which hearing does not involve the swim bladder or other gas volume. These species are susceptible to barotrauma although hearing only involves particle motion, not sound pressure. These fishes detect sounds from below 50 Hz to perhaps 800-1,000 Hz (though several probably detect sounds only to 600-800 Hz). A wide range of species fall into this category, including tuna with swim bladders, sturgeons, salmonids, etc. These species detect both particle motion and pressure, and the differences between species are related to how well the species can use the pressure signal.
- Fishes that have some kind of structure that mechanically couples the inner ear to the swim bladder (or other gas bubble), thereby resulting in detection of a wider bandwidth of sounds and lower intensities than fishes in other groups. These fishes detect sounds up to 3,000 Hz or more. There are not many marine species known to fit in this group, but it may include some species of sciaenids. It is also possible that a number of deep-sea species fall within this category based on

the morphology of their auditory system. Other members of this group would include all of the Otophysan fishes, though few of these species other than catfishes are found in marine waters.

- Fishes in which hearing involves a swim bladder or other gas volume. These species are susceptible to barotrauma and detect sound pressure as well as particle motion. All of these fishes are members of the herring family and their relatives (Clupeiformes). Their hearing below 1,000 Hz is generally similar to fishes in the first group, but their hearing range extends to at least 4,000 Hz, and some species (e.g., American shad) are able to detect sounds to over 180 kHz.

3.7.1.4 Threatened and Endangered Species

Nineteen ESA-listed fish species (comprising 49 distinct species, subspecies, Evolutionarily Significant Units [ESUs], or DPS total) potentially occur throughout the action area (**Table 3.7-1**). Additionally, there is one salmon ESU that is a candidate for listing. Of all the species, two are perch-like, eight are salmonid species, two are scorpionfishes, four are sharks and rays, and three are sturgeons. All but eight of the listed fish also have designated critical habitat (**Table 3.7-1**). There are no federally-listed threatened or endangered fish species present within the Great Lakes.

Table 3.7-1. ESA-Listed Fish Occurring in the Action Area

Common Name	Scientific Name	ESA Status	Lead Agency	Region*	Critical Habitat
Perch-like (Perciformes)					
Nassau grouper	<i>Epinephelus striatus</i>	Threatened	NMFS	SER	No
Tidewater goby	<i>Eucyclogobius newberryi</i>	Endangered	USFWS	WCR	Yes
Salmon, Smelts, etc. (Salmoniformes)					
Atlantic salmon (Gulf of Maine DPS)	<i>Salmo salar</i>	Endangered	USFWS/ NMFS	GAR	Yes
Chinook salmon (California Coastal ESU)	<i>Oncorhynchus tshawytscha</i>	Threatened	NMFS	WCR	Yes
Chinook salmon (Central Valley Spring-run ESU)	<i>Oncorhynchus tshawytscha</i>	Threatened	NMFS	WCR	Yes
Chinook salmon (Lower Columbia River ESU)	<i>Oncorhynchus tshawytscha</i>	Threatened	NMFS	WCR	Yes
Chinook salmon (Puget Sound ESU)	<i>Oncorhynchus tshawytscha</i>	Threatened	NMFS	WCR	Yes
Chinook salmon (Sacramento River Winter-run ESU)	<i>Oncorhynchus tshawytscha</i>	Endangered	NMFS	WCR	Yes
Chinook salmon (Snake River Fall-run ESU)	<i>Oncorhynchus tshawytscha</i>	Threatened	NMFS	WCR	Yes
Chinook salmon (Snake River Spring/Summer-run ESU)	<i>Oncorhynchus tshawytscha</i>	Threatened	NMFS	WCR	Yes

Common Name	Scientific Name	ESA Status	Lead Agency	Region*	Critical Habitat
Chinook salmon (Upper Columbia River Spring-run ESU)	<i>Oncorhynchus tshawytscha</i>	Endangered	NMFS	WCR	Yes
Chinook salmon (Upper Willamette River ESU)	<i>Oncorhynchus tshawytscha</i>	Threatened	NMFS	WCR	Yes
Chinook salmon (Upper Klamath-Trinity River)	<i>Oncorhynchus tshawytscha</i>	Candidate	NMFS	WCR	--
Chum salmon (Columbia River ESU)	<i>Oncorhynchus keta</i>	Threatened	NMFS	WCR	Yes
Chum salmon (Hood Canal Summer-run ESU)	<i>Oncorhynchus keta</i>	Threatened	NMFS	WCR	Yes
Coho salmon (Central California Coast ESU)	<i>Oncorhynchus kisutch</i>	Endangered	NMFS	WCR	Yes
Coho salmon (Lower Columbia River ESU)	<i>Oncorhynchus kisutch</i>	Threatened	NMFS	WCR	Yes
Coho salmon (Oregon Coast ESU)	<i>Oncorhynchus kisutch</i>	Threatened	NMFS	WCR	Yes
Coho salmon (Southern Oregon/Northern California Coast ESU)	<i>Oncorhynchus kisutch</i>	Threatened	NMFS	WCR	Yes
Sockeye salmon (Ozette Lake ESU)	<i>Oncorhynchus nerka</i>	Threatened	NMFS	WCR	Yes
Sockeye salmon (Snake River ESU)	<i>Oncorhynchus nerka</i>	Endangered	NMFS	WCR	Yes
Steelhead (California Central Valley DPS)	<i>Oncorhynchus mykiss</i>	Threatened	NMFS	WCR	Yes
Steelhead (Central California Coast DPS)	<i>Oncorhynchus mykiss</i>	Threatened	NMFS	WCR	Yes
Steelhead (Lower Columbia River DPS)	<i>Oncorhynchus mykiss</i>	Threatened	NMFS	WCR	Yes
Steelhead (Middle Columbia River DPS)	<i>Oncorhynchus mykiss</i>	Threatened	NMFS	WCR	Yes
Steelhead (Northern California DPS)	<i>Oncorhynchus mykiss</i>	Threatened	NMFS	WCR	Yes
Steelhead (Puget Sound DPS)	<i>Oncorhynchus mykiss</i>	Threatened	NMFS	WCR	Yes
Steelhead (Snake River Basin DPS)	<i>Oncorhynchus mykiss</i>	Threatened	NMFS	WCR	Yes

Common Name	Scientific Name	ESA Status	Lead Agency	Region*	Critical Habitat
Steelhead (South Central California Coast DPS)	<i>Oncorhynchus mykiss</i>	Threatened	NMFS	WCR	Yes
Steelhead (Southern California DPS)	<i>Oncorhynchus mykiss</i>	Endangered	NMFS	WCR	Yes
Steelhead (Upper Columbia River DPS)	<i>Oncorhynchus mykiss</i>	Threatened	NMFS	WCR	Yes
Steelhead (Upper Willamette River DPS)	<i>Oncorhynchus mykiss</i>	Threatened	NMFS	WCR	Yes
Bull trout (Coastal Recovery Unit)	<i>Salvelinus confluentus</i>	Threatened	USFWS	WCR	Yes
Eulachon (Southern DPS)	<i>Thaleichthys pacificus</i>	Threatened	NMFS	WCR, AR	Yes
Scorpionfishes (Scorpaeniformes)					
Bocaccio (Puget Sound/Georgia Basin DPS)	<i>Sebastes paucispinis</i>	Endangered	NMFS	WCR, AR	No
Yelloweye rockfish (Puget Sound/Georgia Basin DPS)	<i>Sebastes ruberrimus</i>	Threatened	NMFS	WCR, AR	Yes
Sharks, Skates, Rays, & Chimeras (Chondrichthyes)					
Giant manta ray	<i>Manta birostris</i>	Threatened	NMFS	GAR, SER, PIR	No
Scalloped hammerhead shark (Eastern Pacific DPS)	<i>Sphyrna lewini</i>	Endangered	NMFS	WCR, PIR	No
Scalloped hammerhead shark (Central and Southwest Atlantic DPS)	<i>Sphyrna lewini</i>	Threatened	NMFS	SER	No
Scalloped hammerhead shark (Indo-West Pacific DPS)	<i>Sphyrna lewini</i>	Threatened	NMFS	PIR	No
Largetooth sawfish	<i>Pristis pristis</i>	Endangered	NMFS	SER	No
Smalltooth sawfish	<i>Pristis pectinata</i>	Endangered	NMFS	SER	No
Sturgeons (Acipenseriformes)					
Atlantic sturgeon (New York Bight DPS)**	<i>Acipenser oxyrinchus</i>	Endangered	NMFS	GAR	Yes
Atlantic sturgeon (Carolina DPS)**	<i>Acipenser oxyrinchus</i>	Endangered	NMFS	SER	Yes
Atlantic sturgeon (Chesapeake Bay DPS)**	<i>Acipenser oxyrinchus</i>	Endangered	NMFS	GAR	Yes
Atlantic sturgeon (South Atlantic DPS)**	<i>Acipenser oxyrinchus</i>	Endangered	NMFS	SER	Yes

Common Name	Scientific Name	ESA Status	Lead Agency	Region*	Critical Habitat
Atlantic sturgeon (Gulf of Maine DPS)**	<i>Acipenser oxyrinchus</i>	Threatened	NMFS	GAR	Yes
Atlantic sturgeon (Gulf of Mexico subspecies)	<i>Acipenser oxyrinchus desotoi</i>	Threatened	USFWS/ NMFS	SER	Yes
Green sturgeon (Southern DPS)	<i>Acipenser medirostris</i>	Threatened	NMFS	WCR	Yes
Shortnose sturgeon	<i>Acipenser brevirostrum</i>	Endangered	NMFS	GAR, SER	No

Sources: ECOS, No Date-a; NMFS, No Date-a

*GAR = Greater Atlantic Region (includes the U.S. portions of the Great Lakes, New England, and the mid-Atlantic); SER = Southeast Region (includes the southern portion of the U.S. Eastern Seaboard, the U.S. Caribbean Islands [Puerto Rico and the U.S. Virgin Islands], and the Gulf of Mexico); AR = Alaska Region (includes Alaskan waters and the Arctic); WCR = West Coast Region (includes coastal California, Oregon and Washington); PIR = Pacific Islands Region (includes Hawai'i and territories of the U.S.)

** All five Atlantic sturgeon DPSs mix in the offshore/marine environment (i.e., an adult Atlantic sturgeon encountered in the Atlantic Ocean could be from any one of the five DPSs).

3.7.1.4.1 Nassau Grouper

The Nassau grouper (**Figure 3.7-5**) is a reef fish associated with hard structures such as reefs, rocks, and ledges. They are late-maturing, long-lived, top-level predators. Nassau grouper used to be one of the most common species of grouper in the U.S. but became scarce due to commercial and recreational fishing (NMFS, No Date-a). The remaining stocks are overexploited, but all harvest of Nassau grouper is prohibited in the U.S. Some countries have limited or no regulations in place to protect Nassau grouper.



Figure 3.7-5. Nassau Grouper

Photo Credit: NMFS

The Nassau grouper was listed as threatened under the ESA in 2016. Data are scarce on historical Nassau grouper numbers. Currently, Nassau grouper are occasionally reported during underwater reef surveys at low density. Based on the size and number of current spawning aggregations, the Nassau grouper population appears to be just a fraction of its historical size (NMFS, No Date-a).

Nassau grouper are ambush predators that are not selective with their prey. Adults eat only fish, while juveniles eat a variety of fish and invertebrates (e.g., shrimp and crabs). They take advantage of lower light levels at dawn and dusk, combined with the higher number of prey during changeover between diurnal and nocturnal fishes (NMFS, No Date-a).

Nassau grouper are found in tropical and subtropical waters of the western North Atlantic. This includes Bermuda, Florida, Bahamas, the Yucatan Peninsula, and throughout the Caribbean to southern Brazil. They generally live among shallow reefs, but can be found in depths to 130 m (426 ft) (NMFS, No Date-a). The Nassau grouper is considered a reef fish, but it transitions in habitat and diet as it grows. As larvae, they eat plankton. As juveniles, they are found in nearshore shallow waters in seagrass habitats. They shift deeper as they grow to predominantly reef habitat.

Water clarity, habitat, and benthos are important to determining the distribution of Nassau grouper (NMFS, No Date-a). Their depth range may be influenced more by the availability of suitable habitat than by food resources since their diet is highly varied and has more to do with body size than of water depth. Nassau grouper tend to spend a lot of time in one spot, often on high-relief coral reefs or rocks in clear water. Larger fish tend to occupy deeper reef areas with greater vertical relief. Both adults and juveniles use either natural or artificial reefs.

Nassau grouper spawn in aggregations, gathering in hundreds, thousands, or tens of thousands. The aggregations form from November through February around the full moon when water temperatures are around 26°C (79°F) (NMFS, No Date-a). The timing and synchronization of spawning may be to accommodate widely dispersed adults, facilitate egg dispersal, or reduce predation on adults or eggs. As spawning time approaches, adults move from the reefs where they live to specific spawning areas. Some of them travel only a few kilometers/miles; others are known to travel up to several hundred kilometers to the aggregation sites. Sites have been found near the edges of reefs as little as 46 m (150 ft) from the shore and near drop-offs into deeper water across a wide range of depths (6-60 m [20-200 ft]) and environments (including soft corals, sponges, stony coral outcrops, and sandy depressions).

3.7.1.4.2 Tidewater Goby

The tidewater goby, endemic to California, is a small fish rarely more than 2 inches in length. It was listed as threatened under the ESA in 1994, and critical habitat was designated in 2000. Populations of the tidewater goby are described as being discontinuously distributed along most of the California coast. Tidewater gobies are found spread across their original range; however, within that range, 17 percent of the populations have been extirpated, and 41-52 percent of the populations are so small and degraded that their long-term survival appears uncertain (EPA, 2010). Gaps in distribution along the coast may be natural due to steep coastlines, or due to the extirpation of populations. Because the tidewater goby is adapted to a narrow range of salinity tolerance, the marine environment limits genetic exchange between populations and recolonization of habitat following extirpations.

The tidewater goby is threatened by modification and loss of habitat as a result of coastal development, channelization of habitat, diversions of water flows, groundwater overdrafting, and alteration of water flows (USFWS, 2005). Potential threats to the tidewater goby include discharge of agricultural and sewage effluents, increased sedimentation due to cattle grazing and feral pig activity, summer breaching of lagoons, upstream alteration of sediment flows into the lagoon areas, introduction of exotic gobies (e.g., yellowfin goby [*Acanthogobius flavimanus*] and shimofuri goby [*Tridentiger bifasciatus*]) and rainwater killifish (*Lucina parva*), habitat damage, and watercourse contamination resulting from vehicular activity in the vicinity of lagoons.

Tidewater gobies are nearly unique among Pacific coast fish in that they inhabit the fresh-saltwater interface where salinity is less than 10 to 12 parts per thousand. This occurs both at the upper edge of tidal bays (such as Tomales, Bolinas, and San Francisco Bays) near the entrance of freshwater tributaries and in coastal lagoons formed at the mouths of coastal rivers, streams, and seasonally wet canyons (EPA, 2010). These habitats provide the relatively shallow and still, but not stagnant, water that tidewater gobies prefer. Seasonal variation such as spring floods can scour lagoons, breaching the sandbar barriers established during the previous season, and flushing tidewater gobies into an unfavorable marine environment. The deeper, backwater habitats offer safe harbor for tidewater gobies during the spring floods. Half-grown and adult tidewater gobies may migrate upstream from the estuaries into tributaries, a distance of 0.8 km (0.5 mi) to 5-8 km (3-5 mi) (EPA, 2010).

Upstream locations appear to be used for reproduction, which can occur year-round, peaking in April-May after the lagoons close to the ocean, and again later in summer. Males dig burrows in clean, coarse sand. Females compete with one another for access to these burrows, where they deposit a clutch of eggs. The male goby then remains in the burrow with the eggs until they hatch 9-11 days later (EPA, 2010). For a couple of days, the young hang out in midwater, before becoming benthic (settling to the bottom to live and feed). Tidewater gobies prey on chironomid midge larvae, mysid shrimp, ostracods, and amphipods. In turn, they are prey for young steelhead, staghorn sculpin, tule, and Sacramento perch, nonnative fish such as bass and shimofuri gobies, and many birds such as egrets, herons, mergansers, grebes, and loons (EPA, 2010).

Critical habitat includes stream channels and their associated wetlands, flood plains, and estuaries along the California coast (USFWS, 2005). These habitat areas provide for the primary biological needs of foraging, sheltering, reproduction, and dispersal, which are essential for the conservation of the tidewater goby.

3.7.1.4.3 Atlantic Salmon (Gulf of Maine Distinct Population Segment)

The anadromous Atlantic salmon (**Figure 3.7-6**) are vulnerable to many stressors and threats, including blocked access to spawning grounds, habitat degradation caused by dams and culverts, and poor marine survival (NMFS, No Date-a). They are considered an indicator species: when a river ecosystem is clean and well-connected, its salmon population is typically healthy and robust; when a river ecosystem is not clean or well-connected, its salmon population will usually decline. Atlantic salmon in the U.S. were once native to almost every coastal river northeast of the Hudson River in New York. Commercial fishing reduced their population size until the fisheries closed in 1948. Commercial and recreational fishing for wild sea run Atlantic salmon is still prohibited in the U.S.

Currently, the last wild populations of U.S. Atlantic salmon are found in at least eight rivers in Maine. These populations comprise the Gulf of Maine DPS which was listed as endangered under the ESA in 2009. This DPS includes all naturally reproducing wild populations and those river-specific hatchery populations of Atlantic salmon that have historical, river-specific characteristics. These populations are found north of and including tributaries of the lower Kennebec River to, but not including, the mouth of the St. Croix River at the U.S.-Canada border. Critical habitat was also designated for the Gulf of Maine DPS in 2009. Worldwide, Atlantic salmon populations in single rivers range from thousands to nearly a quarter million; however, some populations are small, numbering in the low hundreds or even single individuals (NMFS, No Date-a).

Figure 3.7-6. Atlantic Salmon



Photo Credit: Design Pics Inc.

Adult Atlantic salmon can migrate several times to spawn, though repeat spawners are becoming increasingly rare (NMFS, No Date-a). They travel long distances from the mouths of rivers to the Atlantic Ocean before returning to their natal rivers. For example, U.S. salmon leave Maine rivers in the spring and reach the seas off Newfoundland and Labrador, Canada, by mid-summer. They spend their first winter at sea south of Greenland and their second growing season at sea off the coast west of Greenland and sometimes east of Greenland. Maturing fish travel back to their native rivers in Maine to spawn after 1 to 3 years. The diet of Atlantic salmon depends on their age. Young salmon eat insects, invertebrates, and plankton. The preferred diet of adult salmon is capelin, which are elongated silvery baitfish.

There are three groups of Atlantic salmon: North American, European, and Baltic (NMFS, No Date-a). These groups are found in the waters of North America, Iceland, Greenland, Europe, and Russia. Atlantic salmon spawn in the coastal rivers of northeastern North America, Iceland, Europe, and northwestern Russia. After spawning, they migrate through various portions of the North Atlantic Ocean. European and North American populations of Atlantic salmon intermix while living in the ocean, where they share summer feeding grounds off Greenland. The North American group historically ranged from northern Quebec to Newfoundland and to Long Island Sound. This group includes Canadian populations and U.S. populations.

Designated critical habitat comprises 45 specific areas in Maine occupied by Atlantic salmon at the time of listing with approximately 19,571 km (12,161 mi) of perennial river, stream, and estuary habitat and 799 km² (308 mi²) of lake habitat within the range of the Gulf of Maine DPS and in which are found those physical and biological features essential to the conservation of the species (74 FR 39903, August 10, 2009). The critical habitat is defined by seven habitat features essential to spawning and rearing and six habitat features essential to migration.

3.7.1.4.4 Pacific Salmon

Pacific salmon are anadromous, with a life cycle occurring in a chain of connected environments as the salmon travel through freshwater streams, estuaries, nearshore areas, and the ocean. Each of these habitats provides crucial elements for the salmon's survival as they cycle through incubation, emergence, freshwater rearing, estuary transition, ocean residence, migration, and spawning. Pacific salmon are also semelparous, meaning that they die after spawning only once. Their total energies are devoted to producing the next generation, and their bodies help enrich the stream for that generation and other wildlife species (NMFS, 2007a).

Salmonid species' homing propensity (their tendency to return to the locations where they originated) creates unique patterns of genetic variation and connectivity among spawning areas across the landscape. Diverse genetic, life history, and morphological characteristics have evolved in salmon over generations, creating runs adapted to diverse environments. Two criteria define an ESU of salmon: (1) it must be substantially reproductively isolated from other conspecific units, and (2) it must represent an important component of the evolutionary legacy of the species. An ESU can contain multiple populations that are connected by some degree of migration, and hence may have a broad geographic range across watersheds, river basins, and political jurisdictions (NMFS, 2013).

For salmon, and other anadromous fish, the essential features of designated critical habitat include substrate, water quality, water quantity, water temperature, food, riparian vegetation, access, water, velocity, space, and safe passage. These features also describe the habitat factors associated with viability for all ESUs (NMFS, 2009). Designated critical habitats for Pacific salmon comprise the specific areas, or portions of the areas, where the runs are located.

3.7.1.4.5 Chinook Salmon (California Coastal Evolutionarily Significant Unit, Central Valley Spring-run Evolutionarily Significant Unit, Lower Columbia River Evolutionarily Significant Unit, Puget Sound Evolutionarily Significant Unit, Sacramento River Winter-run Evolutionarily Significant Unit, Snake River Fall-run Evolutionarily Significant Unit, Snake River Spring/Summer-run Evolutionarily Significant Unit, Upper Columbia River Spring-run Evolutionarily Significant Unit, Upper Willamette River Evolutionarily Significant Unit)

Chinook are the largest of the Pacific salmon species with adults usually exceeding 0.45 kg (40 lbs), and often over 45 kg (100 lbs). Chinook salmon are often referred to as king salmon. They generally spawn between September and January. Wild Chinook salmon populations have been, and continue to be, threatened by a legacy of habitat degradation, hydropower impacts, harvest, and hatchery production (NMFS, 2013). Each listed ESU of Chinook salmon is briefly described below.

The California Coastal ESU was listed as threatened under the ESA in 1999, and critical habitat was designated in 2005. This ESU extends from Redwood Creek (Humboldt County, California) south to the Russian River (Sonoma County, California) (NMFS, 2016b). The ESU was historically composed of 38 populations (32 fall run and six spring run); all six of the spring-run populations in the ESU are now considered extinct. Chinook salmon have declined substantially in coastal populations of central and northern California over the past 70 years, and all life stages of Chinook salmon are impaired by degraded habitat conditions. These impairments are due to a lack of complexity and shelter formed by instream wood, high sediment loads, lack of refugia during winter, low summer flows, reduced quality and extent of coastal estuaries and lagoons, and reduced access to historic spawning and rearing habitat. The major sources of these impairments are roads, water diversions and impoundments, logging, residential and commercial development, severe weather patterns, and channel modification. In 1965, the estimated adult population for this ESU was over 76,000 (NMFS, 2016b). The most current available data indicate ESU and population-level abundances are now considerably lower; but in the Russian River, adult returns have apparently improved in recent years.

The Central Valley Spring-run ESU was listed as threatened under the ESA in 1999, and critical habitat was designated in 2005. This ESU includes naturally spawned spring-run Chinook salmon originating from the Sacramento River in California and its tributaries, and also spring-run Chinook salmon from the Feather River Hatchery Spring-run Chinook Program (NMFS, 2014a). Historically, spring-run Chinook salmon

occurred in the headwaters of all major river systems in the California Central Valley where natural barriers to migration were absent. The Central Valley as a whole is estimated to have supported spring-run Chinook salmon runs as large as 600,000 fish between the late 1880s and 1940s. Beginning in the 1880s, harvest, water development, construction of dams that prevented access to headwater areas, and habitat degradation significantly reduced the number and range of spring-run Chinook salmon. From 1970 through 2012, Central Valley spring-run Chinook salmon annual run size estimates fluctuated from highs near 30,000 to lows near 3,000 (NMFS, 2014a).

The Lower Columbia River ESU was listed as threatened under the ESA in 1999, and critical habitat was designated in 2005. This ESU includes all naturally spawned populations of Chinook salmon from the Columbia River and its tributaries from the river's mouth at the Pacific Ocean upstream to and including the Hood River in Oregon and the White Salmon River in Washington, including the Willamette River to Willamette Falls, Oregon, but excluding spring run Chinook salmon in the Clackamas River (NMFS, 2013). It also includes Chinook salmon from 17 artificial propagation programs. Lower Columbia River Chinook salmon are classified as spring, fall, or late fall based on when adults return to fresh water. Other life history differences among run types include the timing of spawning, incubation, emergence in fresh water, migration to the ocean, maturation, and return to fresh water. This life history diversity allows different runs of Chinook salmon to use streams as small as 3 m (10 ft) wide and rivers as large as the mainstem Columbia River. Depending on run type, Chinook rear for a few months to a year or more in freshwater streams, rivers, or the estuary before migrating to the ocean in spring, summer, or fall. All runs migrate far into the North Pacific on a multi-year journey along the continental shelf to Alaska before circling back to their river of origin. Out of the 32 populations that make up this ESU, only the two late-fall runs, the North Fork Lewis and Sandy, are considered viable. Most populations (26 out of 32) have a very low probability of persistence over the next 100 years, and some have been extirpated or nearly so (NMFS, 2013).

The Puget Sound ESU was listed as threatened under the ESA in 1999; critical habitat was designated in 2005. This ESU includes the Nooksack River in the north to southern Puget Sound, including the Hood Canal, and extends westerly out the Strait of Juan de Fuca to the Elwha River in Washington (NMFS, 2007a). The Skagit River and its tributaries constitute what was historically the predominant system in Puget Sound containing naturally spawning populations. Although 22 populations of Chinook salmon have been identified in Puget Sound, historically it is believed that there may have been 30-37 populations or spawning aggregations. Threats to the ESU include access to important spawning and rearing areas eliminated as a result of dams, culverts and other barriers, and fragmented, modified, and lost habitat. Chinook populations in the Nooksack, Lake Washington, mid-Hood Canal, Puyallup, and Dungeness basins have recently had returns of less than 200 adult fish annually. Only two populations, the Upper Skagit and Green/Duwamish have had annual average returns in excess of 10,000 adult Chinook (NMFS, 2007a).

The Sacramento River Winter-run ESU was first listed as threatened under the ESA in 1989 and reclassified as endangered in 1994; critical habitat was designated in 1993. This ESU includes winter-run Chinook salmon spawning naturally in the Sacramento River and its tributaries in California, as well as winter-run Chinook salmon that are part of the conservation hatchery program at the Livingston Stone National Fish Hatchery (NFH) (NMFS, 2014a). Winter-run Chinook salmon are unique because they spawn during summer months when air temperatures usually approach their yearly maximum. A major factor affecting Chinook salmon in the Central Valley was hydraulic gold mining, which began in the 1850s. By 1859, an estimated 8,000 km (5,000 mi) of mining flumes and canals diverted streams used by salmonids for spawning and nursery habitat, and an estimated 1.5 billion cubic yards of debris was sluiced into the streams and rivers of the Central Valley. Additionally, one of the main threats to the Sacramento River

winter-run Chinook salmon ESU is that it consists of only one small population. This population declined from nearly 100,000 spawners in the late 1960s to fewer than 200 in the early 1990s. In 2017, the population estimate was an average of 1,155 returning winter-run Chinook salmon (CDFW, 2018).

The Snake River Fall-run ESU was listed as threatened under the ESA in 1992; critical habitat was designated in 1993. This ESU includes all natural-origin fall-run Chinook salmon from the mainstem Snake River below Hells Canyon Dam (the lowest of three impassable dams that form the Hells Canyon Complex) and from the Tucannon River, Grande Ronde River, Imnaha River, Salmon River, and Clearwater River subbasins in Idaho, Oregon, and Washington (NMFS, 2017a). Fall-run Chinook salmon from four artificial propagation programs are also considered part of the ESU: Lyons Ferry Hatchery Program, Fall Chinook Acclimation Ponds Program, Nez Perce Tribal Hatchery Program, and the Oxbow Hatchery Program. At one time approximately half a million adult fall Chinook salmon traveled 485 km (300 mi) up the Columbia River and into the Snake River basin each year. The fish spawned throughout the 965-km (600-mi) reach of the mainstem Snake River from its confluence with the Columbia River upstream to Shoshone Falls, as well as in several major tributaries. The fall Chinook salmon run began to decline in the late 1800s and continued to decline through the 1900s as a result of overfishing and other human activities including the construction of major dams on the mainstem Snake River and tributaries that barred fish access to primary spawning and rearing habitats. By the late 1980s, average runs of natural-origin fall Chinook salmon to the Snake River had dropped to approximately 100 adults annually. Only about 78 natural-origin adult fish returned to spawn in 1990. The abundance for the 10 years of annual spawner estimates from 2005-2014 is approximately 6,400 adult fish (NMFS, 2017a).

The Snake River Spring/Summer-run ESU was listed as threatened under the ESA in 1992, and critical habitat was designated in 1993. This ESU includes all naturally spawned spring/summer Chinook salmon originating from the mainstem Snake River and the Tucannon River, Grande Ronde River, Imnaha River, and Salmon River subbasins, as well as spring/summer Chinook salmon from 11 hatchery programs in Idaho, Oregon, and Washington (NMFS, 2017b). Spring/summer-run Chinook salmon from the Snake River basin represent two of four different seasonal (i.e., spring, summer, fall, or winter) runs in the Chinook salmon migration from the ocean to fresh water. These runs reflect the timing of when adult Chinook salmon enter fresh water to begin their spawning migration. Historically, the Snake River was the Columbia River basin's most productive drainage for salmon, supporting more than 40 percent of all Columbia River spring and summer Chinook salmon. Rates of harvest on the runs soared in the late 1800s and early 1900s, but deterioration of habitat conditions due to logging, mining, grazing, farming, hydropower development, and other practices led to declines and, along with migration barriers, continue to threaten the ESU salmon. While the historical run in the Snake River likely exceeded 1 million fish annually in the late 1800s, the run declined to near 100,000 adults per year by the 1950s, reaching a low of 2,200 fish in 1995 (NMFS, 2017b).

The Upper Columbia River Spring-run ESU was listed as endangered under the ESA in 2005, and critical habitat was also designated in 2005. This ESU includes naturally spawned spring-run Chinook salmon originating from Columbia River tributaries upstream of the Rock Island Dam and downstream of Chief Joseph Dam (excluding the Okanogan River subbasin), as well as spring-run Chinook salmon from six artificial propagation programs in Washington (NMFS, 2007b). The ESU includes three extant populations (Wenatchee, Entiat, and Methow), as well as one extinct population in the Okanogan subbasin. Populations of spring Chinook within the Upper Columbia River Basin were first affected by the intensive commercial fisheries in the lower Columbia River in the latter half of the 1800s and into the 1900s. Human population growth within the basin was increasing and land uses and the construction of dams and diversions, some without passage, blocked salmon migrations, isolated or fragmented populations, and

killed upstream and downstream migrating fish. At that time of listing, fish counts were declining severely, and the individual 31 populations within the ESU were small, with none averaging more than 150 adults annually. Trends were mostly downward and a few local populations exhibited rates of decline exceeding 20 percent per year. Since 2000, adult spring Chinook numbers have increased in the Upper Columbia Basin (NMFS, 2007b).

The Upper Willamette River ESU was listed as endangered under the ESA in 2005, and critical habitat was also designated in 2005. This ESU includes naturally spawned spring-run Chinook salmon originating from the Clackamas River and from the Willamette River and its tributaries above Willamette Falls, as well as spring-run Chinook salmon from six artificial propagation programs in Oregon (NMFS, 2011). Of the seven populations that historically comprised this ESU, the subbasins supporting these populations are tributaries within the Willamette River basin, but current significant natural production occurs in only the Clackamas and McKenzie populations. Flood control/hydropower development has blocked or impaired fish passage for adults and juveniles, caused loss of some riverine habitat and associated functional connectivity due to reservoirs, reduced in stream flow volume due to water withdrawals, altered physical habitat structure, and altered water temperature and flow regimes. The ESU is considered to be extremely depressed, likely numbering less than 10,000 adult fish annually compared to a historical abundance estimate of 300,000 (NMFS, 2011).

3.7.1.4.6 Chum Salmon (Columbia River Evolutionarily Significant Unit and Hood Canal Summer-run Evolutionarily Significant Unit)

Chum salmon are second only to Chinook salmon in adult size, with individuals reported up to 43 inches in length and 21 kg (46 lbs) in weight (with an average around 4 to 7 kg (8 to 15 lbs) (NMFS, 2007a). Chum salmon are often referred to as dog salmon. Chum salmon spend more of their life history in marine waters than any other Pacific salmonid species. Also, unlike other salmon species, chum salmon form schools. Threats include widespread loss of estuary and lower floodplain habitat, negative interactions with hatchery fish, and high predation by marine mammals (NMFS, 2007a). The Columbia River and Hood Canal summer-run ESUs were listed as threatened under the ESA in 1999. Critical habitat for both chum salmon ESUs was designated in 2005.

The Columbia River ESU includes all naturally spawned populations of chum salmon in the Columbia River and its tributaries in Oregon and Washington and chum salmon from three artificial propagation programs. Columbia River chum salmon once were widely distributed throughout the lower Columbia Basin and spawned in the mainstem Columbia and the lower reaches of most lower Columbia River tributaries. Historically, spawning occurred as far upstream as the Umatilla and Walla Walla rivers, but it now is restricted largely to tributary and mainstem areas downstream of Bonneville (NMFS, 2013). Although chum salmon are strong swimmers, they rarely pass river blockages and waterfalls that pose no hindrance to other salmon; thus, they spawn in low-gradient, low-elevation reaches and side channels. Adult chum salmon returning to the Columbia River at the present time are virtually all fall-run fish, entering fresh water from mid-October through November and spawning from early November to late December. Over the last century, Columbia River chum salmon returns have collapsed from hundreds of thousands to just a few thousand per year. Of the 17 populations that historically made up this ESU, 15 of them (six in Oregon and nine in Washington) are so depleted that either their baseline probability of persistence is very low or they are extirpated or nearly so. Currently, almost all natural production occurs in just two populations: the Grays/Chinook and the Lower Gorge (NMFS, 2013).

The Hood Canal summer-run ESU includes all naturally spawned populations of summer-run chum salmon in tributaries to the Hood Canal and in Discovery Bay, Sequim Bay, and the Dungeness River on the Strait

of Juan de Fuca in Washington (NMFS, 2007a). Sixteen historic populations comprise the Hood Canal summer-run chum ESU, of which eight currently have existing runs. Threats to the ESU include access to important spawning and rearing areas eliminated as a result of dams, culverts, and other barriers, and fragmented, modified, and loss of habitat. Hood Canal and Strait of Juan de Fuca summer chum experienced a severe drop in abundance in the 1980s, and returns decreased to all-time lows in 1989 and 1990 with less than a thousand spawners each year. Population estimates of summer chum in Hood Canal and Strait of Juan de Fuca streams ranges from a low of 10 spawners in Jimmycomelately Creek to just over 4,500 in the Big/Little Quilcene River (NMFS, 2007a).

3.7.1.4.7 Coho Salmon (Central California Coast Evolutionarily Significant Unit, Lower Columbia River Evolutionarily Significant Unit, Oregon Coast Evolutionarily Significant Unit, Southern Oregon/Northern California Coast Evolutionarily Significant Unit)

Coho salmon (**Figure 3.7-7**) are often referred to as silver salmon. The anadromous life cycle for coho salmon begins in their home stream, normally a small tributary with moderate to low gradient stream reaches. After emerging from the gravel, the small fish seek cool, slow moving stream reaches with quiet areas such as backwater pools, beaver ponds, and side channels. Juveniles generally spend one summer and a winter in these rearing areas before migrating towards the ocean as smolts in the spring, typically from late April until early June (NMFS, 2016c). Most adult coho salmon return to natal tributaries from September to November as 3-year-old fish, after spending two summers in the ocean. Coho salmon have been, and continue to be, threatened by habitat degradation, hydropower impacts including water diversions, harvest, and hatchery production.



Figure 3.7-7. Coho Salmon

Photo Credit: NMFS

The Central California Coast ESU was listed as threatened under the ESA in 1996, and critical habitat was designated in 1999. This ESU occurs on California's central coast which extends from Punta Gorda in southern coastal Humboldt County south to Aptos Creek in Santa Cruz County and includes the San Francisco Bay estuary and its tributaries (except for the Sacramento-San Joaquin Rivers) where coho salmon historically occurred, but are now extirpated (NMFS, 2012). The low survival of juveniles in fresh water, in combination with poor ocean conditions, has led to the precipitous declines of populations in this ESU. Human population growth and land use changes threaten California's salmon habitats. Many streams lack sufficient water or habitat complexity, and are dammed, channelized, or polluted, making it more difficult for salmonids to survive. Other factors such as ocean harvest, bycatch, and hatchery

practices have also had adverse impacts to salmonid survival. The abundance of the Central California Coast ESU was estimated at 200,000 to 500,000 in 1940 but at 2,000 to 3,000 wild adults in 2011 (NMFS, 2012).

The Lower Columbia River ESU was listed as threatened under the ESA in 1999, and critical habitat was designated in 2016. This ESU includes all naturally spawned populations of coho salmon in the lower Columbia River and its tributaries, from the mouth of the Columbia upstream to and including the Hood River (in Oregon) and the White Salmon River (in Washington), and including the Willamette River up to Willamette Falls (NMFS, 2013). It also includes Coho salmon from 25 artificial propagation programs. Lower Columbia River coho salmon are typically categorized into early- and late-returning stocks. Early-returning adult coho salmon enter the Columbia River in mid-August and begin entering tributaries in early September, with peak spawning from mid-October to early November. Late-returning coho salmon pass through the lower Columbia from late September through December and enter tributaries from October through January. Most spawning occurs from November to January, but some occurs as late as March. Out of the 24 populations that make up this ESU, 21 are considered to have a very low probability of persisting for the next 100 years, and none is considered viable (NMFS, 2013).

The Oregon Coast ESU was listed as threatened under the ESA in 1998, and critical habitat was designated in 2008. This ESU includes the Pacific Ocean and the freshwater and estuarine habitat (rivers, streams, and lakes) along the Oregon Coast from the Necanicum River on the north to the Sixes River on the south (NMFS, 2016c). Rivers in the ESU flow from the mountains of the Coast Range, with the exception of the Umpqua River, which extends east through the Coast Range to drain the Cascade Mountains. Most of the rivers transition to estuaries before reaching the Pacific Ocean. In 1850, coho salmon were far more abundant than Chinook salmon in the majority of Oregon coastal watersheds. Runs of coho salmon to these coastal rivers and streams were likely only approached, or exceeded, by runs of chum salmon in rivers along the northern portion of the Oregon coast. Pre-development coho salmon runs to the Oregon Coast may have been in the range of 1 to 2 million fish or more during periods of favorable ocean conditions. Oregon Coast coho salmon were the most numerous species harvested in commercial and recreational fisheries off the Oregon coast during the 1950s and through the 1970s. All-time low returns occurred in the 1970s and 1990s – around 20,000 coho salmon spawners annually – which could be as low as one percent of some of the predevelopment run sizes. Since the mid-1990s, Oregon Coast coho spawner abundance levels have varied greatly (NMFS, 2016c).

The Southern Oregon/Northern California Coast ESU was listed as threatened under the ESA in 1997, and critical habitat was designated in 1999. This ESU includes all naturally spawned populations of coho salmon in coastal streams between Cape Blanco, Oregon and Punta Gorda, California, as well as coho salmon produced by three artificial propagation programs: Cole Rivers Hatchery, Trinity River Hatchery, and Iron Gate Hatchery (NMFS, 2014b). Currently, over three quarters of the coho salmon in 40 populations of this ESU are at high risk due to the combined effects of fish harvest, hatcheries, hydropower operations, and habitat alterations caused by land management that led to declines in these populations. The Rogue River is the only river in the ESU with data on coho abundance from the 1800s. Based on extrapolations from cannery pack data, up to 114,000 adult coho salmon returned to the Rogue River in the late 1800s even after heavy fishing pressure had occurred for years. The estimated number of adult coho salmon spawners that returned to the Rogue River from 1980 to 2010 ranged from less than 1,000 per year up to 25,000 per year (NMFS, 2014b).

3.7.1.4.8 Sockeye Salmon (Ozette Lake Evolutionarily Significant Unit, Snake River Evolutionarily Significant Unit)

Sockeye salmon are the second most abundant of the seven Pacific salmon species (NMFS, 2015b). Sockeye salmon are often referred to as red salmon. Sockeye salmon are generally anadromous, but distinct populations of non-anadromous sockeye also exist; these fish are commonly referred to as kokanee or silver trout. The vast majority of sockeye salmon populations spawn in or near lakes. Spawning can take place in lake tributaries, lake outlets, rivers between lakes, and on lake shorelines or beaches where suitable upwelling or intra-gravel flow is present. Spawn timing is often determined by water temperature. In spawning habitats with cooler water temperatures, sockeye salmon typically spawn earlier (August) than in warmer habitats (November). In North America, sockeye salmon spawn from the Columbia River north to the Noatak River in Alaska (NMFS, 2015b).

The Ozette Lake ESU was listed as threatened under the ESA in 1999, and critical habitat was designated in 2005. The listing was primarily attributed to concerns over abundance and effects of small population genetic and demographic variability. Ozette Lake ESU sockeye spawn in Ozette Lake or its tributaries on the Olympic Peninsula at the western edge of Washington State (NMFS, 2009). The lake, its perimeter shore, and most of the Ozette River, which forms the outlet of the lake to estuary and Pacific Ocean, are included in the 373,120-hectare (ha) (922,000-acre [ac]) Olympic National Park. The Ozette Lake ESU is made up of only one population, which currently contains five distinct spawning aggregations or subpopulations. The subpopulations can be grouped according to whether they spawn in tributaries (Umbrella Creek, Big River, and Crooked Creek) or near lake beaches (Olsen's Beach and Allen's Beach). Overall abundance of the Ozette Lake ESU is low, and degraded habitat conditions represent a limiting factor for this ESU. Between 1996 and 1999, the Ozette Lake ESU run size averaged 2,590 sockeye annually, while from 2000 to 2003 the run size averaged just over 4,600 sockeye. Within these two 4-year cycles, the average return increased by approximately 78 percent between the first and second period (NMFS, 2009).

The Snake River ESU was listed as endangered under the ESA in 1999, and critical habitat was designated in 1993. The last remaining Snake River sockeye salmon spawn in Sawtooth Valley lakes, high in the Salmon River drainage of central Idaho in the Snake River basin. While very few sockeye salmon there currently follow an anadromous life cycle, the small remnant run of the historical population migrates 1,450 km (900 mi) downstream from the Sawtooth Valley through the Salmon, Snake and Columbia Rivers to the ocean. After one to three years in the ocean, they return to the Sawtooth Valley as adults, passing once again through these mainstem rivers and through eight major federal dams, four on the Columbia River and four on the lower Snake River (NMFS, 2015b). Before the turn of the twentieth century, large runs of sockeye salmon returned annually to the Snake River basin. When Snake River ESU sockeye salmon were ESA-listed in 1991, all of the Snake River populations but one, the Redfish Lake population in the Sawtooth Valley, were gone, and that population had dwindled to fewer than 10 fish per year. Between 1999 and 2007, more than 355 adult Snake River sockeye salmon from captive broodstock releases returned to Redfish Lake from the ocean. These returns increased to 1,579 by 2014 (NMFS, 2015b). Threats still include overfishing, irrigation diversions, obstacles to migrating fish, and eradication through poisoning.

3.7.1.4.9 Steelhead

Steelhead trout (**Figure 3.7-8**) are a unique species in that individuals develop differently depending on their environment. They are closely related to Pacific salmon (i.e., in the same genus taxonomically). All steelhead trout hatch in gravel-bottomed, fast-flowing, well-oxygenated rivers and streams. Some stay in

fresh water all their lives and are called rainbow trout (NMFS, No Date-a). Steelhead that migrate to the ocean typically grow larger than the ones that stay in fresh water; they then return to fresh water to spawn. Steelhead are vulnerable to many stressors and threats including blocked access to spawning grounds, habitat degradation caused by dams and culverts, loss of freshwater and estuarine habitat, and periodic poor ocean conditions.

Figure 3.7-8. Steelhead



Photo Credit: NMFS

Steelhead was listed under the ESA between 1998 and 2007, with one DPS listed as endangered and 10 DPS listed as threatened (see **Table 3.7-1**). Additionally, the Middle Columbia River non-essential experimental population is listed as threatened, the Northern California Summer Population is an ESA candidate, and the Klamath Mountains Province steelhead is under ESA review. All the listed steelhead populations have associated designated habitat. The following describes the final steelhead species determinations (71 FR 834, January 5, 2006), abundance, and critical habitat designations (70 FR 52488, September 2, 2005 and 70 FR 52630, September 2, 2005):

The Southern California DPS is the only DPS listed as endangered and includes all naturally spawned populations of steelhead in streams from the Santa Maria River south to the U.S. border with Mexico. The historical steelhead run for four of the major river systems within the range of this DPS is estimated to have been between 32,000 and 46,000 adults. Recent run size for the same four systems has been estimated to be fewer than 500 total adults. Of 65 river drainages where steelhead are known to have occurred historically, between 26 and 52 percent are still occupied. Approximately 1,132 km (708 mi) of stream habitat are designated as critical habitat within the geographical area presently occupied by the Southern California DPS.

The South-Central California Coast DPS includes all naturally spawned populations of steelhead in streams from the Pajaro River to, but not including, the Santa Maria River. There is a paucity of abundance information for this DPS. In general, these river systems are much degraded and are expected to have steelhead runs reduced in size from historical levels. Steelhead is present in approximately 86 to 95 percent of historically occupied streams. Approximately 2,000 km (1,249 mi) of stream habitat and 8 km² (3 mi²) of estuarine habitat are designated as critical habitat within the geographical area presently occupied by the South-Central California Coast DPS.

The Central California Coast DPS includes all naturally spawned populations of steelhead in coastal streams from the Russian River to Aptos Creek, and the drainages of San Francisco, San Pablo, and Suisun

Bays eastward to Chipps Island at the confluence of the Sacramento and San Joaquin Rivers; and tributary streams to Suisun Marsh exclusive of the Sacramento-San Joaquin River Basin of the California Central Valley. Two artificial propagation programs are also considered to be part of the DPS: the Don Clausen Fish Hatchery and Kingfisher Flat Hatchery/Scott Creek (Monterey Bay Salmon and Trout Project) steelhead hatchery. There are no population abundance data for the naturally spawning component of this DPS. The naturally spawning population in the largest river system in the DPS, the Russian River, is believed to have declined seven-fold since the mid-1960s. Steelhead are present in approximately 82 percent of historically occupied streams. Approximately 2,344 km (1,465 mi) of stream habitat and 386 mi² (996 km²) of estuarine habitat are designated as critical habitat within the geographical area presently occupied by the Central California Coast DPS.

The California Central Valley DPS includes all naturally spawned populations of steelhead in the Sacramento and San Joaquin Rivers and their tributaries, excluding steelhead from San Francisco and San Pablo Bays and their tributaries. Two artificial propagation programs are considered to be part of the DPS: the Coleman NFH and Feather River Hatchery. It is estimated that on average during 1998–2000, approximately 181,000 juvenile steelhead were produced naturally each year in the Central Valley by approximately 3,600 spawning female steelhead. It is estimated that there were 1 to 2 million spawners in the Central Valley prior to 1850, and approximately 40,000 spawners in the 1960s. Although steelhead remain widely distributed in Sacramento River tributaries, the vast majority of historical spawning areas are currently above impassable dams. Approximately 3,693 km (2,308 mi) of stream habitat and 254 mi² (655 km²) of estuarine habitat are designated as critical habitat within the geographical area presently occupied by the California Central Valley DPS.

The Northern California DPS includes all naturally spawned populations of steelhead in coastal river basins from Redwood Creek southward to, but not including, the Russian River. Two artificial propagation programs are considered part of the DPS: the Yager Creek Hatchery and North Fork Gualala River Hatchery. Abundance levels range from three to 418 adults, and exhibit downward short- and long-term trends. Despite low abundance and downward trends, steelhead appear to be still widely distributed throughout this DPS. Approximately 4,844 km (3,028 mi) of stream habitat and 65 km² (25 mi²) of estuarine habitat are designated as critical habitat within the geographical area presently occupied by the Northern California DPS.

The Upper Willamette River DPS includes all naturally spawned populations of winter-run steelhead in the Willamette River, Oregon, and its tributaries upstream from Willamette Falls to the Calapooia River in Oregon. Abundance for this DPS is approximately 5,800 adults, and individual populations remain at low abundance. Long-term trends in abundance are negative for all populations in the DPS; short-term trends, buoyed by recent strong returns, are positive. Approximately one-third of the DPS's historically accessible spawning habitat is now blocked, but the DPS continues to be spatially well distributed. Approximately 2,054 km (1,276 mi) of stream habitat and 5.2 km² (2 mi²) of lake habitat are designated as critical habitat within the geographical area presently occupied by the Upper Willamette River DPS.

The Lower Columbia River DPS includes all naturally spawned populations of steelhead in streams and tributaries to the Columbia River between the Cowlitz and Wind Rivers, Washington, and the Willamette and Hood Rivers, Oregon. Ten artificial propagation programs are considered to be part of the DPS: the Cowlitz Trout Hatchery (in the Cispus, Upper Cowlitz, Lower Cowlitz, and Tilton Rivers), Kalama River Wild (winter- and summer-run), Clackamas Hatchery, Sandy Hatchery, and Hood River (winter- and summer-run). Population abundance levels are small with no population having greater than 750 spawners annually. Four historical populations have been extirpated or nearly extirpated, and only half of 23

historical populations currently exhibit appreciable natural production. Although approximately 35 percent of historical habitat has been lost within the range of this DPS due to the construction of dams or other impassable barriers, the DPS exhibits a broad spatial distribution in a variety of watersheds and habitat types. Approximately 3,740 km (2,324 mi) of stream habitat and 70 km² (27 mi²) of lake habitat are designated as critical habitat within the geographical area presently occupied by the Lower Columbia River DPS.

The Middle Columbia River DPS includes all naturally spawned populations of steelhead in streams from above the Wind River, Washington, and the Hood River, Oregon, upstream to, and including, the Yakima River, Washington. Seven artificial propagation programs are considered part of the DPS: the Touchet River Endemic, Yakima River Kelt Reconditioning Program (in Satus Creek, Toppenish Creek, Naches River, and Upper Yakima River), Umatilla River, and the Deschutes River. The abundance of some natural populations in this DPS has increased substantially in recent years. Long-term trends for 11 of the 12 production areas within the range of the DPS were negative, but short-term trends in the 12 production areas were mostly positive from 1990 to 2001. Steelhead remain well distributed in the majority of sub-basins within the range of the DPS. Approximately 9,358 km (5,815 mi) of stream habitat are designated as critical habitat within the geographical area presently occupied by the Middle Columbia River DPS.

The Upper Columbia River DPS includes all naturally spawned populations of steelhead in streams in the Columbia River Basin upstream from the Yakima River, Washington, to the U.S.-Canada border. Six artificial propagation programs are considered part of the DPS: the Wenatchee River, Wells Hatchery (in the Methow and Okanogan Rivers), Winthrop NFH, Omak Creek, and the Ringold hatchery program. The 1996–2001 average return through the Priest Rapids Dam fish ladder was approximately 12,900 total adults compared to 7,800 adults for 1992–1996, but predominantly composed of hatchery-spawners rather than naturally spawning fish. Approximately 2,031 km (1,262 mi) of stream habitat and 18 km² (7 mi²) of lake habitat are designated as critical habitat within the geographical area presently occupied by the Upper Columbia River DPS.

The Snake River Basin DPS includes all naturally spawned populations of steelhead in streams in the Snake River Basin of southeast Washington, northeast Oregon, and Idaho. Six artificial propagation programs are considered part of the DPS: the Tucannon River, Dworshak NFH, Lolo Creek, North Fork Clearwater, East Fork Salmon River, and the Little Sheep Creek/Imnaha River Hatchery. The abundance of steelhead return has been generally improved, such as the return over Lower Granite Dam which was substantially higher in 2001 (14,768 natural returns) relative to the low levels in the 1990s. The DPS remains spatially well distributed in each of the six major geographic areas in Snake River Basin. Approximately 12,954 km (8,049 mi) of stream habitat and 10 km² (4 mi²) of lake habitat are designated as critical habitat within the geographical area presently occupied by the Snake River Basin DPS.

The Puget Sound DPS includes naturally spawned populations of steelhead originating below natural and manmade impassable barriers from rivers flowing into Puget Sound from the Elwha River eastward, including rivers in Hood Canal, South Sound, North Sound and the Strait of Georgia in Washington. Six artificial propagation programs are considered part of the DPS: the Green River, the White River, the Hood Canal (in the Dewatto, Skokomish, and Duckabush Rivers), and the Lower Elwha recovery program. Estimates of mean population growth rates are declining, typically three to ten percent annually. Approximately 3,269 km (2,031 mi) of stream habitat are designated as critical habitat within the geographical area presently occupied by the Puget Sound DPS.

3.7.1.4.10 Bull Trout

Bull trout are native to waters in western North America. In the U.S., bull trout range widely through the Columbia River and Snake River basins, extending east to headwater streams in Idaho and Montana, into Canada and southeast Alaska, and to the Puget Sound and Olympic Peninsula watersheds of western Washington and the Klamath River basin of south-central Oregon (USFWS, 2015). Historically bull trout also occurred in the Sacramento River basin in California.

Bull trout exhibit both resident and migratory life histories. Resident forms of bull trout complete their entire life cycle in the tributary streams in which they spawn and rear. Migratory bull trout spawn in tributary streams, where juvenile fish rear for one to four years before migrating to either a lake, river, or in certain coastal areas, to saltwater. Bull trout typically spawn from August to November during periods of decreasing water temperatures. Resident and migratory forms may be found together, and either form may give rise to offspring exhibiting either resident or migratory behavior (USFWS, 2015).

Currently, 109 occupied bull trout core areas exist. Complex core areas contain multiple local populations; they are typically situated in a larger patch of habitat, often occupied by bull trout of both the migratory life history form and the resident form, and include a diverse pattern of connected spawning and rearing habitats and foraging, migratory, and overwintering habitats (USFWS, 2015). Simple core areas contain a single local population; typically, they are situated in a smaller patch of habitat that may not include foraging, migratory, and overwintering stream habitat and sometimes include only the resident life history form or a very simple migratory pattern.

All populations of bull trout were listed as threatened under the ESA in 1999. Of the 121 core areas in which bull trout populations were evaluated, 23 exhibited population trends that were declining from slightly to severely, 18 were stable, 14 were increasing, and 66 were unknown (USFWS, 2015). Critical habitat was designated in 2004 and most recently revised in 2010. The decline of bull trout is primarily due to habitat degradation and fragmentation, blockage of migratory corridors, poor water quality, past fisheries management practices, impoundments, dams, water diversions, and the introduction of nonnative species.

Of native salmonids in the Pacific Northwest, bull trout have the most specific habitat requirements. These requirements include cold water temperatures compared to other salmonids (often less than 12°C [54°F]); the cleanest stream substrates; complex stream habitat including deep pools, overhanging banks and large woody debris; and connectivity between spawning and rearing areas and downstream foraging, migratory, and overwintering habitats (USFWS, 2015). Habitat components that influence bull trout distribution and abundance include water temperature, cover, channel form and stability, valley form, spawning and rearing substrate, and migratory corridors.

Bull trout are opportunistic feeders, with food habits primarily a function of size and life history strategy. Resident and juvenile migratory bull trout prey on terrestrial and aquatic insects, macro-zooplankton, and small fish. Adult migratory bull trout feed primarily on a wide variety of resident and anadromous fish species. In coastal areas of western Washington, bull trout feed on forage fish species such as Pacific herring, Pacific sand lance, and surf smelt in near shore marine areas and the ocean (USFWS, 2015).

Designated critical habitat comprises 31,751 km (19,729 mi) of streams (which includes 1,213 km [754 mi]) of marine shoreline in the Olympic Peninsula and Puget Sound), and 197,589 hectares (488,252 acres) of reservoirs and lakes of bull trout habitat (75 FR 63898, October 18, 2010). These areas contain 32 critical

habitat units which reflect single core areas or groups of core areas that are in close proximity geographically (USFWS, 2015). The PCEs (i.e., the specific elements of physical or biological features that provide for a species' life-history processes and are essential to the conservation of the species) upon which the critical habitat areas are designated are:

- 1) Space for individual and population growth and for normal behavior;
- 2) Food, water, air, light, minerals, or other nutritional or physiological requirements;
- 3) Cover or shelter;
- 4) Sites for breeding, reproduction, or rearing (or development) of offspring; and
- 5) Habitats that are protected from disturbance or are representative of the historical, geographical, and ecological distributions of a species.

3.7.1.4.11 Eulachon (Southern Distinct Population Segment)

Eulachon are a small, anadromous fish endemic to the Pacific Ocean and are found from northern California to southwest and south-central Alaska. Eulachon have many other names: smelt, hooligan, oolichan, and candlefish. Native people continue to fish for eulachon by traditional methods for use as an important subsistence food and medicine. Threats to the eulachon include climate change, habitat degradation, habitat impediments, fisheries interaction and bycatch, and water pollution (NMFS, 2017c).

The Southern DPS of eulachon is composed of fish that spawn in rivers south of the Nass River in British Columbia to, and including, the Mad River in California. This DPS was listed as threatened under the ESA in 2010, and critical habitat was designated in 2011. There are no reliable abundance estimates for eulachon. Spawning stock biomass estimations of eulachon in the Columbia River for the years 2000 through 2017 have ranged from a low of 783,400 fish in 2005 to a high of 185,965,200 fish in 2013, with an estimated 18,307,100 fish in 2017 (NMFS, 2017c). Spawning stock biomass estimations of eulachon in the Fraser River for the years 1995 through 2017 have ranged from a low of 109,129 to 146,606 fish in 2010 to a high of 41,709,035 to 56,033,332 fish in 1996, with an estimated 763,330 to 1,026,251 fish in 2017.

Eulachon commonly spawn at age three or four. They generally spawn once, although some individuals may spawn twice in a lifetime. Spawning appears to take place at night and can occur at various depths up to 7 m (25 ft) or more. Spawning substrates can range from silt, sand, or gravel to cobble and detritus. Spawning rivers may be turbid or clear, but all have spring freshets characteristic of rivers draining large snow packs or glaciers. In many rivers, the spawning reach is more or less limited to the part of the river that is influenced by tides. Entry into the spawning rivers appears to be related to water temperature and the occurrence of high tides. Eulachon typically spend several years in salt water before returning to fresh water as a run to spawn from late winter through early summer. Some eulachon runs are very reliable from year to year; others occur more sporadically (NMFS, 2017c).

Numerous populations of eulachon spawn in rivers from northern California to southwestern Alaska. In the portion of the species' range that lies south of the U.S.-Canada border, most eulachon production originates in the Columbia River Basin, including the Columbia River, the Cowlitz River, the Grays River, the Kalama River, the Lewis River, and the Sandy River (NMFS, 2017c). Historically, the only other large river basins in the contiguous U.S. where large, consistent spawning runs of eulachon have been documented are the Klamath River in northern California and the Umpqua River in Oregon. In Alaska, at least 35 rivers

have spawning runs of eulachon, including one in a glacial stream on Unimak Island, the first island in the Aleutian Island chain off the western end of the Alaska Peninsula.

Although they spend 95 to 98 percent of their lives at sea, little is known about the saltwater existence of eulachon. Once juvenile eulachon enter the ocean, they move from shallow nearshore areas to deeper areas over the continental shelf. Larvae and young juveniles become widely distributed in coastal waters, where they are typically found near the ocean bottom in waters 20 to 150 m (66 to 492 ft) deep (NMFS, 2017c).

The PCEs for the Southern DPS fall into three major categories reflecting key life history phases of eulachon (76 FR 65324, October 20, 2011): 1) freshwater spawning and incubation sites with water flow, quality and temperature conditions and substrate supporting spawning and incubation, and with migratory access for adults and juveniles; 2) freshwater and estuarine migration corridors associated with spawning and incubation sites that are free of obstruction and with water flow, quality and temperature conditions supporting larval and adult mobility, and with abundant prey items supporting larval feeding after the yolk sac is depleted; and 3) nearshore and offshore marine foraging habitat with water quality and available prey, supporting juveniles and adult survival. Based on these features, 16 specific areas consisting of 539 km (335 mi) of riverine and estuarine habitat in California, Oregon, and Washington within the geographical area occupied by the southern DPS of eulachon were designated as critical habitat. No specific marine areas meet the definition of critical habitat, nor were any unoccupied areas identified that may be essential to the conservation of the Southern DPS.

3.7.1.4.12 Bocaccio and Yelloweye Rockfish (Puget Sound/Georgia Basin Distinct Population Segment)

Yelloweye rockfish (**Figure 3.7-9**) and bocaccio occupy the waters of the Pacific coast from California to Alaska. Yelloweye rockfish are among the longest lived of rockfishes, living up to 118 years. Rockfish are slow-growing, late to mature, and long-lived. Historical overfishing has been the primary cause of the decline of rockfishes in Puget Sound; additional threats include bycatch, degraded water quality and habitat, contaminants, and derelict fishing gear (NMFS, 2017d).



Figure 3.7-9.
Yelloweye Rockfish

Photo Credit: California Department of Fish and Wildlife

The Puget Sound/Georgia Basin DPS of yelloweye rockfish was listed as threatened and bocaccio was listed as endangered under the ESA in 2010. The DPSs include all yelloweye rockfish and bocaccio found in waters of Puget Sound, the Strait of Georgia, and the Strait of Juan de Fuca east of Victoria Sill in Washington. The yelloweye rockfish DPS extends further north than bocaccio into the waters of Johnstone Strait. Critical habitat was designated for both species in 2014. The best available data indicate that the

total rockfish population in the Puget Sound region is estimated to have declined approximately three percent per year for the past several decades, corresponding to an approximate 70 percent decline from 1965 to 2007. The decline of yelloweye rockfish and bocaccio is estimated to be greater than the 70 percent observed in the total rockfish decline during that time period (NMFS, 2017d).

Rockfish are mid-level predators with diverse diets that include many species of marine invertebrates and fish (NMFS, 2017d). Larval and juvenile rockfish feed on very small organisms such as zooplankton, particularly copepods, phytoplankton, small crustaceans, invertebrate eggs, and krill. Rockfishes of all sizes are an important food resource for a variety of predators in Puget Sound including numerous fish species, birds, and several marine mammals.

Rockfish have multiple reproductive cycles during their lifetime and are typically long-lived. This trait allows the adult population to persist through many years of poor reproduction until a good recruitment year occurs, likely dictated by climatic or oceanic conditions. Rockfish are viviparous, meaning the eggs are fertilized internally, the embryonic fish develop within the mother, and the young are released as larvae. Larval rockfish are often observed under free-floating algae, seagrass, and detached kelp, and also occupy the full water column (NMFS, 2017d). Generally, juvenile rockfish move from the pelagic environment and associate with benthic environments when they reach approximately the age of three to six months. As they grow, juveniles gradually move to areas of rocky habitat in deeper waters. Juvenile yelloweye rockfish are not typically found in intertidal waters, but rather in habitats along the shallow range of adult habitats. Juvenile bocaccio occurs on shallow rocky reefs and nearshore areas.

As adults, rockfish generally inhabit relatively deep waters with rugged, steep, and complex bathymetry, though they may also occur over less complex habitat or in the water column in association with sheer walls (NMFS, 2017d). Rockfish commonly occupy reef habitats, though are also found on complex soft bottom or in association with subtidal vegetation. Adult yelloweye rockfish and bocaccio frequently occupy habitats within and adjacent to areas that are highly rugged, but yelloweye rockfish have also been documented in areas with mud and mud/cobble habitats, and bocaccio also occupy benthic areas with soft-bottomed habitats, particularly those adjacent to structure such as boulders and crevices. Adult yelloweye rockfish remain near the substrate and have relatively small home ranges, while some bocaccio have larger home ranges, move long distances, and spend time suspended in the water column. Adult yelloweye rockfish and bocaccio generally occupy habitats from approximately 30 to 425 m (90 to 1,394 ft).

The specific areas designated as critical habitat for bocaccio total approximately 1,617 km² (1,005 mi²) of deepwater (>30 m [98 ft]) and nearshore (<30 m [98 ft]) marine habitat in Puget Sound. The specific areas designated for yelloweye rockfish include 666 km² (414 mi²) of deepwater marine habitat in Puget Sound, all of which overlap with areas designated for bocaccio (NMFS, 2017d). The PCEs for yelloweye rockfish and bocaccio include sites deeper than 30 m (98 ft) that possess or are adjacent to areas of complex bathymetry, and juvenile settlement sites located in the nearshore with substrates such as sand, rock, and/or cobble compositions that also support kelp and eelgrass.

3.7.1.4.13 Giant Manta Ray

The giant manta ray (**Figure 3.7-10**) is the world's largest ray with a wingspan of up to 9 m (29 ft). Manta rays are filter feeders and eat large quantities of zooplankton. Giant manta rays are slow-growing, migratory animals with small, highly fragmented populations that are sparsely distributed across the world (NMFS, No Date-a). The main threat to the giant manta ray is commercial fishing, with the species both targeted and caught as bycatch in a number of global fisheries. Additionally, demand for the gills of

manta rays has risen dramatically in Asian markets, leading to large harvests and declines in population of the species.

Figure 3.7-10. Giant Manta Ray



Photo Credit: George Schmah

The giant manta ray was listed as threatened under the ESA in 2018. Information on the global distribution of giant manta rays and their population sizes is lacking. Regional population sizes are small, ranging from around 100 to 1,500 individuals (NMFS, No Date-a). In areas subject to fishing, giant manta ray populations have significantly declined. Ecuador is thought to be home to the largest population of giant manta ray, with large aggregation sites within the waters of the Machalilla National Park and the Galapagos Marine Reserve.

The giant manta ray is a migratory species seasonally found along productive coastlines with regular upwelling, in oceanic island groups, and near offshore pinnacles and seamounts. The timing when giant manta rays occur in these locations varies by region and seems to correspond with the movement of zooplankton, current circulation and tidal patterns, seasonal upwelling, seawater temperature, and possibly mating behavior (NMFS, No Date-a). Although the giant manta ray tends to be solitary, individuals aggregate to feed and mate. Manta rays primarily feed on planktonic organisms such as euphausiids, copepods, mysids, decapod larvae and shrimp, and moderately sized fish. Giant manta rays exhibit a high degree of plasticity in terms of their use of depths within their habitat. During feeding, giant manta rays may aggregate in shallow waters at depths less than 10 m (33 ft). However, they may also dive up to 200 to 450 m (656 to 1,476 ft) and are capable of diving to depths exceeding 1,000 m (3,281 ft). This diving behavior may be influenced by season and shifts in prey location associated with the thermocline.

The giant manta ray is found worldwide in tropical, subtropical, and temperate waters and is commonly found offshore, in oceanic waters, and near productive coastlines. Off the U.S. east coast, giant manta rays are commonly found in waters from 19 to 22°C (66 to 72°F) whereas those off the Yucatan peninsula and Indonesia are commonly found in waters between 25 to 30°C (77 to 86°F) (NMFS, No Date-a). The giant manta ray has also been observed in estuarine waters near oceanic inlets, with use of these waters as potential nursery grounds.

3.7.1.4.14 Scalloped Hammerhead Shark (Eastern Pacific Distinct Population Segment, Central and Southwest Atlantic Distinct Population Segment, and Indo-West Pacific Distinct Population Segment)

Scalloped hammerhead sharks are moderately large sharks with a global distribution. The most distinguishing characteristic of this shark is its hammer-shaped head. They are threatened by commercial fishing, mainly for the shark fin trade. Scalloped hammerhead sharks are both targeted and taken as bycatch in many global fisheries. They are targeted by semi-industrial, artisanal and recreational fisheries, and caught as bycatch in pelagic longline tuna and swordfish fisheries and purse seine fisheries (NMFS, 2014c). Since the scalloped hammerhead shark range is composed of open ocean environments occurring over broad geographic ranges, large-scale impacts such as global climate change that affect ocean temperatures, currents, and potentially food chain dynamics are most likely to pose the greatest threat to this species.

The Central and Southwest Atlantic DPS and the Indo-West Pacific DPS of scalloped hammerhead shark were listed as threatened and the Eastern Pacific DPS was listed as endangered under the ESA in 2014. Current population sizes are available for the scalloped hammerhead shark but are considered qualitative indicators rather than precise estimates. Population estimates vary from 142,000 to 169,000 in 1981 to 24,000 to 29,000 in 2005 (NMFS, 2014c). Data from multiple sources indicate that the Atlantic population experienced the most severe declines over the past few decades, with the northwestern Atlantic and Gulf of Mexico stocks depleted by approximately 83 percent since 1981.

The scalloped hammerhead shark lives in coastal warm temperate and tropical seas. It occurs over continental and insular shelves, as well as adjacent deep waters, but is seldom found in waters cooler than 22°C (72°F) (NMFS, 2014c). It ranges from the intertidal and surface to depths of up to 450-512 m (1,476-1,680 ft) with occasional dives to even deeper waters. It has also been documented entering enclosed bays and estuaries. Scalloped hammerhead sharks are highly mobile, partly migratory, and are likely the most abundant of the hammerhead species. These sharks make migrations along continental margins as well as between oceanic islands in tropical waters. Both juveniles and adult scalloped hammerhead sharks occur as solitary individuals, pairs, or in schools. The scalloped hammerhead shark is a high trophic level predator and opportunistic feeder with a diet that includes a wide variety of fish, cephalopods, crustaceans, and rays. The species is viviparous (i.e., give birth to live young) with a gestation period of 9 to 12 months. Females move inshore to birth, with litter sizes anywhere between one and 40 live pups (NMFS, 2014c).

The scalloped hammerhead shark can be found in coastal warm temperate and tropical seas worldwide. In the western Atlantic Ocean, the scalloped hammerhead range extends from the northeast coast of the U.S. (from New Jersey to Florida) to Brazil, including the Gulf of Mexico and Caribbean Sea. Distribution in the eastern Pacific Ocean extends from the coast of southern California, including the Gulf of California, to Ecuador and possibly Peru, and off waters of Hawai'i and Tahiti (NMFS, 2014c). The habitat of adult scalloped hammerheads consists of continental areas further offshore, with adult aggregations common over seamounts and near islands like the Galapagos, Malpelo, Cocos and Revillagigedo Islands, and within the Gulf of California. Many of these islands are considered hot spots for both juvenile and adult scalloped hammerhead sharks and are also designated as marine reserves.

3.7.1.4.15 Largetooth Sawfish and Smalltooth Sawfish

Although shark-like in appearance, sawfish are actually rays, as their gills and mouths are found on the underside of their bodies. Largetooth sawfish and smalltooth sawfish are the two species of sawfish that have historically inhabited U.S. waters in the Gulf of Mexico mainly along the Texas coast and east into

Florida waters, though largetooth sawfish have not been found in the U.S. in 50 years (NMFS, No Date-a). The largetooth sawfish has the largest historical range of all sawfish species, but its populations have dramatically declined worldwide due to habitat loss, entanglement in fishing gear, and low population growth. In the present day, largetooth sawfish are thought to primarily occur in freshwater habitats in Central and South America and Africa.

The largetooth sawfish was first listed as endangered under the ESA in 2011. Taxonomic changes to the sawfishes resulted in the largetooth sawfish known as *P. pristis* being revised to include the species formerly known as *P. microdon* and *P. perotetti* and being listed again in 2014. Though reported in the U.S., it appears that the largetooth sawfish was never abundant, with approximately 39 confirmed records (33 in Texas) from 1910 through 1961 and no confirmed sightings since then (NMFS, 2010).

Smalltooth sawfish look very similar to largetooth sawfish, and it can be hard to tell the two species apart. Smalltooth sawfish live in tropical seas and of the Atlantic Ocean in shallow, coastal waters and sometimes the lower reaches of freshwater river systems. Smalltooth sawfish populations have declined dramatically due to habitat loss associated with coastal development and accidental capture in fisheries. The smalltooth sawfish was the first marine fish to receive federal protection as an endangered species under the ESA in 2003. Under the ESA, it is illegal to catch, harm, harass, or kill an endangered sawfish; however, some fishermen catch sawfish as bycatch (NMFS, No Date-a).

Sawfish eat a variety of fish and invertebrates (e.g., shrimp and crabs). They use their rostra, the long flat snout edged with teeth, to slash through schools of fish, swinging it from side to side to impale and stun prey. Their rostra also contain electro-sensitive organs, which can sense the weak amount of electricity produced by other animals (NMFS, No Date-a). Sawfish are yolk-sac viviparous, meaning that their young are attached to yolk sacs that nourish the embryo inside the mother's body and emerge fully developed. They are born with their saw fully developed, but it is very flexible and sheathed in a thick gelatinous material to avoid injuring the mother at birth. Sawfish reach sexual maturity at around seven years and when they have grown to about 3 m (11 ft) long.

Largetooth sawfish are generally restricted to shallow (<10 m [33 ft]) coastal, estuarine, and fresh waters, although they have been found at depths of up to 122 m (400 ft) (NMFS, 2010). Largetooth sawfish are often found in brackish water near river mouths and large bays, preferring partially enclosed waters, lying in deeper holes and on bottoms of mud or muddy sand. This species, like the smalltooth sawfish, is highly mangrove-associated. While it is thought that they spend most of their time on the bottom, they are commonly observed swimming near the surface. Largetooth sawfish move across salinity gradients freely and appear to have more physiological tolerance of fresh water than smalltooth sawfish. Though their habitats once overlapped in the northern Gulf of Mexico, the largetooth sawfish historically had a more southerly range than the smalltooth sawfish, with what appears to be a narrower seasonal migration pattern.

Smalltooth sawfish were once found in the Gulf of Mexico from Texas to Florida and along the East Coast from Florida to North Carolina. Their distribution has decreased greatly in U.S. waters over the past century, and the species is only found now off the coast of Florida from about Charlotte Harbor through the Everglades region at the southern tip of the state (NMFS, No Date-a). Outside the U.S., smalltooth sawfish have been confirmed to live in the Bahamas and Sierra Leone (a single confirmed record). However, informal reports suggest they might also be found off the coasts of Honduras, Belize, Cuba, and Guinea Bissau.

Smalltooth sawfish use a variety of coastal habitats depending on life stage. During their first two years, juveniles live in estuaries and the smaller habitats within them, such as shallow portions of bays, lagoons, and rivers (NMFS, No Date-a). Once they reach 2 m (7 ft), they move out of the shallow estuaries into more coastal habitats. Larger juveniles and adults can be found in estuaries, off beaches, and along deep-water reefs. Generally, smalltooth sawfish live in waters warmer than 18°C (64°F).

3.7.1.4.16 Atlantic Sturgeon (New York Bight Distinct Population Segment, Carolina Distinct Population Segment, Chesapeake Bay Distinct Population Segment, South Atlantic Distinct Population Segment, Gulf of Maine Distinct Population Segment, and Gulf subspecies)

The anadromous Atlantic sturgeon (**Figure 3.7-11**) lives in rivers and coastal waters from Canada to Florida. Atlantic sturgeon are slow-growing, late-maturing, and long-lived and have been recorded to reach up to 4 m (14 ft) in length and up to 60 years of age (NMFS, No Date-a). Atlantic sturgeon were once found in great abundance, and their eggs were valued as high-quality caviar. During the late 1800s, the sturgeon fishery was known as the Black Gold Rush for its caviar. By the beginning of the 1900s, sturgeon populations had declined drastically. Close to 3,175,147 kg (7 million lbs) of sturgeon were reportedly caught in 1887, but by 1905 the catch declined to only 9,071 kg (20,000 lbs), and by 1989 only 181 kg (400 lbs) of sturgeon were recorded (NMFS, No Date-a). The primary threats currently facing Atlantic sturgeon are entanglement in fishing gear, habitat degradation, habitat impediments such as dams and other barriers, and vessel strikes.

All five U.S. Atlantic sturgeon DPSs were listed under the ESA in 2012. Atlantic sturgeon that hatch out in Gulf of Maine rivers are listed as threatened, and those that hatch out in other U.S. rivers are listed as endangered. Critical habitat for all five DPSs was designated in 2017. Additionally, the Gulf of Mexico subspecies (also known as the Gulf sturgeon) was listed as threatened in 1991, with critical habitat designated in 2003.

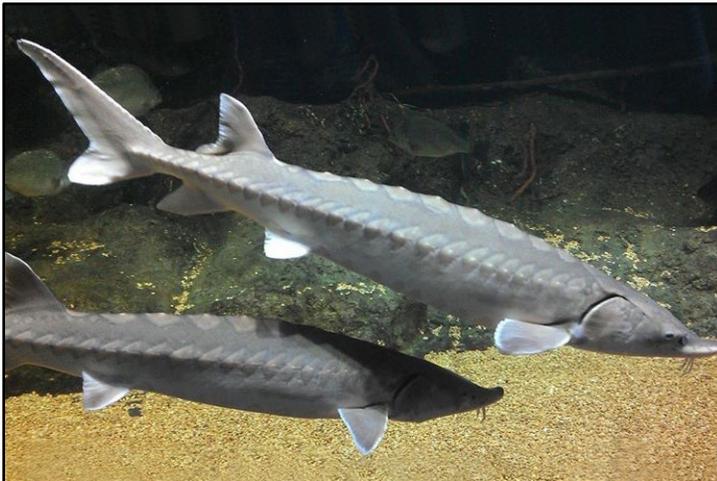


Figure 3.7-11. Atlantic Sturgeon

Photo Credit: NMFS

In rivers from Georgia to the Chesapeake Bay, adult sturgeon generally spawn during the late summer and fall. However, there are also spring-spawning males in the James River, VA (Balazik et al., 2017) and in the Edisto River, SC (Farrae et al., 2017), as well as spring and fall spawning in the Altamaha River, Georgia (Ingram and Peterson, 2016). In rivers from Delaware to Canada, adults spawn in the spring and early summer. Adult Atlantic sturgeon migrate along the coast when not spawning and preferentially use estuaries. Juvenile fish can leave their natal rivers as early as one year of age, and juvenile aggregations

within a river may be composed of two or more different natal populations of fish. After spawning in northern rivers, males may remain in the river or lower estuary until the fall; females typically exit the rivers within four to six weeks after spawning. In southern rivers, males usually enter the river in late summer when temperatures can be as high as 32°C (90°F), spawn as river temperatures approach 21-24°C (70-75°F), with females leaving immediately after spawning and males leaving as temperatures drop below 18°F (65°F) (NMFS, No Date-a). Upon hatching, larvae hide along the bottom and drift downstream until they reach brackish waters where they may reside for one to five years before moving into nearshore coastal waters. Atlantic sturgeon are bottom feeders with a diet consisting of invertebrates such as crustaceans, worms, and mollusks, and bottom-dwelling fish.

Historically, Atlantic sturgeon ranged in major estuaries and river systems along the Canadian and U.S. Atlantic Coast from Labrador to Florida. While still found throughout their historical range, Atlantic sturgeon spawning is known to occur in only 22 of 38 historical spawning rivers from Maine to Georgia and in several more in Canada (NMFS, No Date-a). Atlantic sturgeon are anadromous fish born in fresh water, then migrating to the sea and back again to fresh water to spawn. Most juveniles remain in their river of birth for at least several months before migrating out to the ocean. Tagging data indicate that these immature Atlantic sturgeon travel widely up and down the East Coast, and as far as Iceland, when they are at sea.

In designating critical habitat for the Gulf of Maine, New York Bight, and Chesapeake Bay DPSs, a key conservation objective is to increase the abundance of each DPS by facilitating increased successful reproduction and recruitment to the marine environment and essential physical features: 1) hard bottom substrate; 2) aquatic habitat with a gradual downstream salinity gradient of 0.5 up to as high as 30 ppt and soft substrate; 3) water of appropriate depth and absent physical barriers to passage; and 4) water, between the river mouth and spawning sites, especially in the bottom meter of the water column, with appropriate temperature, salinity, and oxygen values (82 FR 39160, August 17, 2017). For the Carolina and South Atlantic DPSs of Atlantic sturgeon, the key conservation objectives are to increase the abundance of each DPS by facilitating increased survival of all life stages and facilitating adult reproduction and juvenile and subadult recruitment into the adult population, and essential physical features: 1) hard bottom substrates; 2) transitional salinity zones inclusive of waters with a gradual downstream gradient of 0.5– up to 30 ppt and soft substrate; 3) water of appropriate depth and absent physical barriers to passage; and 4) water quality conditions, especially in the bottom meter of the water column, between the river mouths and spawning sites with appropriate temperature and oxygen values (82 FR 39160, August 17, 2017). Specific occupied areas designated as critical habitat for these five DPSs is described in the Federal Register final rule notice (82 FR 39160, August 17, 2017).

The Gulf of Mexico subspecies inhabits coastal rivers from Louisiana to Florida during the warmer months and overwinters in estuaries, bays, and the Gulf of Mexico (68 FR 13370, March 19, 2003). Historically, the Gulf sturgeon occurred from the Mississippi River east to Tampa Bay. Its present range extends from Lake Pontchartrain and the Pearl River system in Louisiana and Mississippi east to the Suwannee River in Florida. Sporadic occurrences have been recorded as far west as the Rio Grande River between Texas and Mexico, and as far east and south as Florida Bay. In fresh water, they are typically found on sandbars and sand shoals over rippled bottom and in shallow, relatively open, unstructured areas. Estuarine and marine habitat consists of unvegetated sandy shoreline, sandbars, or shoals, with water depths less than 3.5 m (11.5 ft) and deep holes near passes in intertidal and subtidal energy zones.

The PCEs essential for the conservation of the Gulf sturgeon upon which the critical habitat areas are designated are: 1) abundant food items; 2) riverine spawning sites with substrates suitable for egg

deposition and development; 3) riverine aggregation areas, also referred to as resting, holding, and staging areas; 4) a flow regime necessary for normal behavior, growth, and survival of all life stages in the riverine environment; 5) water quality necessary for normal behavior, growth, and viability of all life stages; 6) sediment quality necessary for normal behavior, growth, and viability of all life stages; and 7) safe and unobstructed migratory pathways necessary for passage within and between riverine, estuarine, and marine habitats (68 FR 13370, March 19, 2003). The areas designated as critical habitat for the Gulf sturgeon provide one or more of these PCEs consisting of seven units of riverine habitat along 2,783 river km (1,730 river mi) and seven units of estuarine and marine habitat in 6,042 km² (2,333 mi²).

3.7.1.4.17 Green Sturgeon (Southern Distinct Population Segment)

The green sturgeon is an anadromous, long-lived, slow-growing fish native to the Pacific Ocean. Spawning and juvenile rearing occurs in rivers, followed by migrating to saltwater to feed, grow, and mature before returning to fresh water to spawn. Green sturgeon are vulnerable to many stressors and threats including blocked access to spawning grounds caused by dams and culverts, habitat degradation, modification, and loss, fishing and bycatch (NMFS, No Date-a).

The green sturgeon Southern DPS, consisting of coastal and Central Valley populations south of the Eel River in California, was listed as threatened under the ESA in 2006. Data suggest that the spawning population of the Southern DPS is smaller than the Northern DPS, which is consistent with the threatened listing for the Southern, but not the Northern, DPS. The spawning population of the Southern DPS in the Sacramento River congregates in a limited area of the river compared to potentially available habitat. The reason for this is unknown, and it is concerning given that a catastrophic or targeted poaching event impacting just a few holding areas could affect a significant portion of the adult population. Critical habitat was designated for the Southern DPS of green sturgeon in 2009.

Green sturgeon range from the Bering Sea, Alaska, to Ensenada, Mexico, with abundance increasing north of Point Conception, CA. Green sturgeon occupy freshwater rivers from the Sacramento River up through British Columbia, but spawning has been confirmed in only three rivers, the Rogue River in Oregon and the Klamath and Sacramento rivers in California (74 FR 52300, October 9, 2009). Southern DPS green sturgeon typically spawn every 3-4 years, and spawning occurs primarily in the Sacramento River. Adult Southern DPS green sturgeon enter San Francisco Bay in late winter through early spring and spawn from April through early July, with peaks of activity influenced by factors including water flow and temperature. Spawning primarily occurs in cool sections of the upper mainstem Sacramento River in deep pools containing small to medium sized gravel, cobble or boulder substrate.

Subadult and adult green sturgeon spend most of their life in the coastal marine environment, typically in waters less than 100 m (328 ft) (Erickson and Hightower, 2007). Southern DPS green sturgeon are found in high concentrations in coastal bays and estuaries along the West Coast during the summer and autumn, particularly in Willapa Bay, Grays Harbor, and the Columbia River estuary (74 FR 52300, October 9, 2009). Southern DPS green sturgeon generally inhabit specific areas of coastal estuaries near or within deep channels or holes, moving into the upper reaches of the estuary, but rarely into fresh water. Green sturgeon in these estuaries may move into tidal flats areas, particularly at night, to feed. Prey species for juvenile, subadult, and adult green sturgeon within bays and estuaries primarily consist of benthic invertebrates and fishes, including crangonid shrimp, burrowing shrimp, amphipods, isopods, clams, annelid worms, crabs, sand lances, and anchovies.

The primary constituent elements for the Southern DPS upon which critical habitat is designated are food resources, substrate type and size, water flow, water quality, migratory corridor, sediment quality, and

water depth applicable to freshwater riverine systems, estuarine areas, and coastal marine areas. Critical habitat is designated for approximately 515 km (320 mi) of riverine habitat and 2,323 km² (897 mi²) of estuarine habitat in California, Oregon, and Washington, and 29,581 km² (11,421 mi²) of coastal marine habitat off California, Oregon, and Washington within the geographical area presently occupied by the Southern DPS of green sturgeon. It is also designated on approximately 784 km (487 mi) of habitat in the Sacramento-San Joaquin Delta, and 350 km² (135 mi²) of habitat within the Yolo and Sutter bypasses, adjacent to the Sacramento River, California (74 FR 52300, October 9, 2009).

3.7.1.4.18 Shortnose Sturgeon

Shortnose sturgeon live in rivers and coastal waters from Canada to Florida. Like other sturgeons, shortnose sturgeon are slow-growing and late-maturing, and they have been recorded to reach up to 1.3 m (4.5 ft) in length and live 30 years or more (NMFS, No Date-a). Unlike Atlantic sturgeon, they tend to spend relatively little time in the ocean. When they do enter marine waters, they generally stay close to shore. In the spring, adults move far upstream and away from saltwater to spawn. After spawning, the adults move rapidly back downstream to the estuaries, where they feed, rest, and spend most of their time. In the mid-1800s, Atlantic and shortnose sturgeon began to support a thriving and profitable fishery for caviar, smoked meat, and oil. By the late-1800s, sturgeon were being over-exploited; in 1890, over 3,175,147 kg (7 million lbs) of sturgeon were caught in one year alone. In 1920, only 10,433 kg (23,000 lbs) of sturgeon were caught (NMFS, No Date-a). Although shortnose sturgeon is no longer fished, threats remain that continue to affect recovery efforts. Bycatch in commercial fisheries and increased industrial uses (e.g., hydropower, nuclear power, treated sewage disposal) of the nation's large coastal rivers during the 20th century became the primary barriers to shortnose sturgeon recovery. Other threats to this species are habitat degradation, water pollution, dredging, water withdrawals, fisheries bycatch, and habitat impediments such as dams.

The shortnose sturgeon was first listed as endangered under the Endangered Species Preservation Act in 1967. No estimate of the historical population size of shortnose sturgeon is available. While shortnose sturgeon were rarely the target of a commercial fishery, they were often taken incidentally in the commercial fishery for Atlantic sturgeon. In the 1950s, sturgeon fisheries declined on the East Coast, which resulted in a lack of records of shortnose sturgeon. Currently, shortnose sturgeon are found in 41 rivers and bays along the east coast, spawning in 19 of those rivers and comprising three metapopulations, or reproductively isolated groups. These three metapopulations include the Carolinian Province (southern metapopulation), Virginian Province (mid-Atlantic metapopulation), and Acadian Province (northern metapopulation) (NMFS, No Date-a). Their distribution across this range is broken up, with a large gap of about 400 km (250 mi) separating the northern and mid-Atlantic metapopulations from the southern metapopulation.

Historically, shortnose sturgeon were found in the coastal rivers along the east coast of North America from the Saint John River in New Brunswick, Canada, to the St. Johns River in Florida, and perhaps as far south as the Indian River in Florida (NMFS, No Date-a). In the southern metapopulation, shortnose sturgeon are currently found in the Great Pee Dee, Waccamaw, Edisto, Cooper, Santee, Altamaha, Ogeechee, and Savannah rivers. They may also be found in the Black, Sampit, Ashley, Roanoke, and Cape Fear rivers, as well as Albemarle Sound and Pamlico Sound. Shortnose sturgeon used to be considered extinct in the Satilla, St. Marys, and the St. Johns rivers, but were recently found again in both the Satilla and St. Marys rivers (NMFS, No Date-a). In the northern and mid-Atlantic metapopulations, shortnose sturgeon are currently found in the Saint John (Canada), Penobscot, Kennebec, Androscoggin, Piscataqua, Merrimack, Connecticut, Hudson, Delaware, and Potomac rivers. They have also been frequently spotted opportunistically foraging and transiting in the St. George, Medomak, Damariscotta, Sheepscot, Saco,

Deerfield, East, and Susquehanna rivers. On rare occasions, they have been seen in the Narraguagus, Presumpscot, Westfield, Housatonic, Schuylkill, Rappahannock, and James rivers (NMFS, No Date-a).

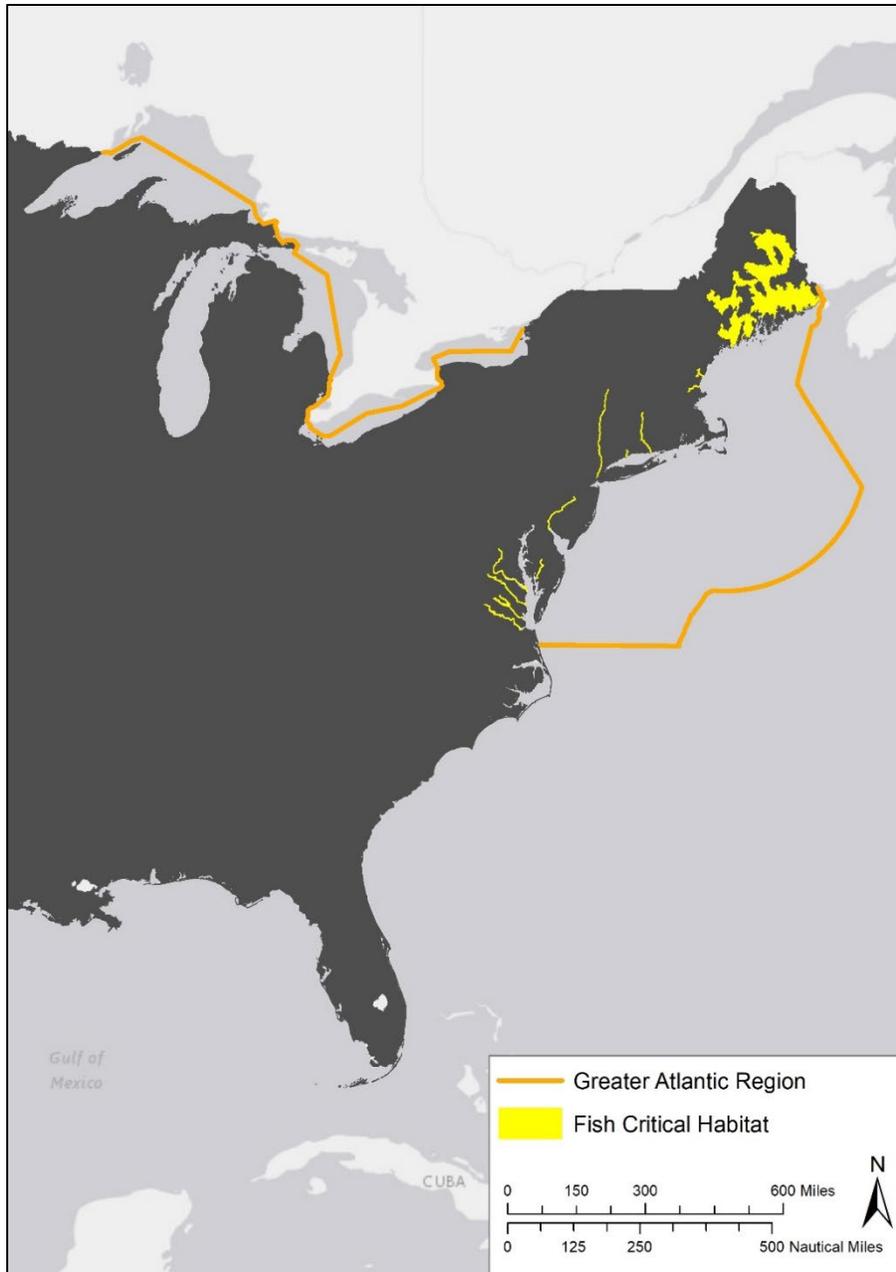
Spawning adults generally migrate upriver in spring, from January to April in the south, April to May in the Mid-Atlantic, and May to June in Canadian waters (NMFS, No Date-a). After spawning, the adults typically move quickly back downstream to the lower river and estuaries. Juveniles move downstream and live in brackish waters for a few months. Shortnose sturgeon search for food in the sandy, muddy bottom of rivers. They use a vacuum-like mouth to suck up this bottom-dwelling food, typically eating invertebrates such as insects, crustaceans, worms, and mollusks.

3.7.1.5 Regional Distribution

This section summarizes region-specific ESA-listed species and critical habitat. General fish assemblages are discussed in Section 3.7.1.1.

3.7.1.5.1 Greater Atlantic Region

Six ESA-listed fish species (Atlantic salmon, giant manta, Atlantic sturgeon – New York Bight DPS, Atlantic sturgeon – Chesapeake Bay DPS, Atlantic sturgeon – Gulf of Maine DPS, and shortnose sturgeon) occur in the Greater Atlantic Region, as indicated in **Table 3.7-1**. The Atlantic salmon and three DPSs of Atlantic sturgeon also have designated critical habitat in the region as shown in **Figure 3.7-12**, much of it occurring in inland rivers.

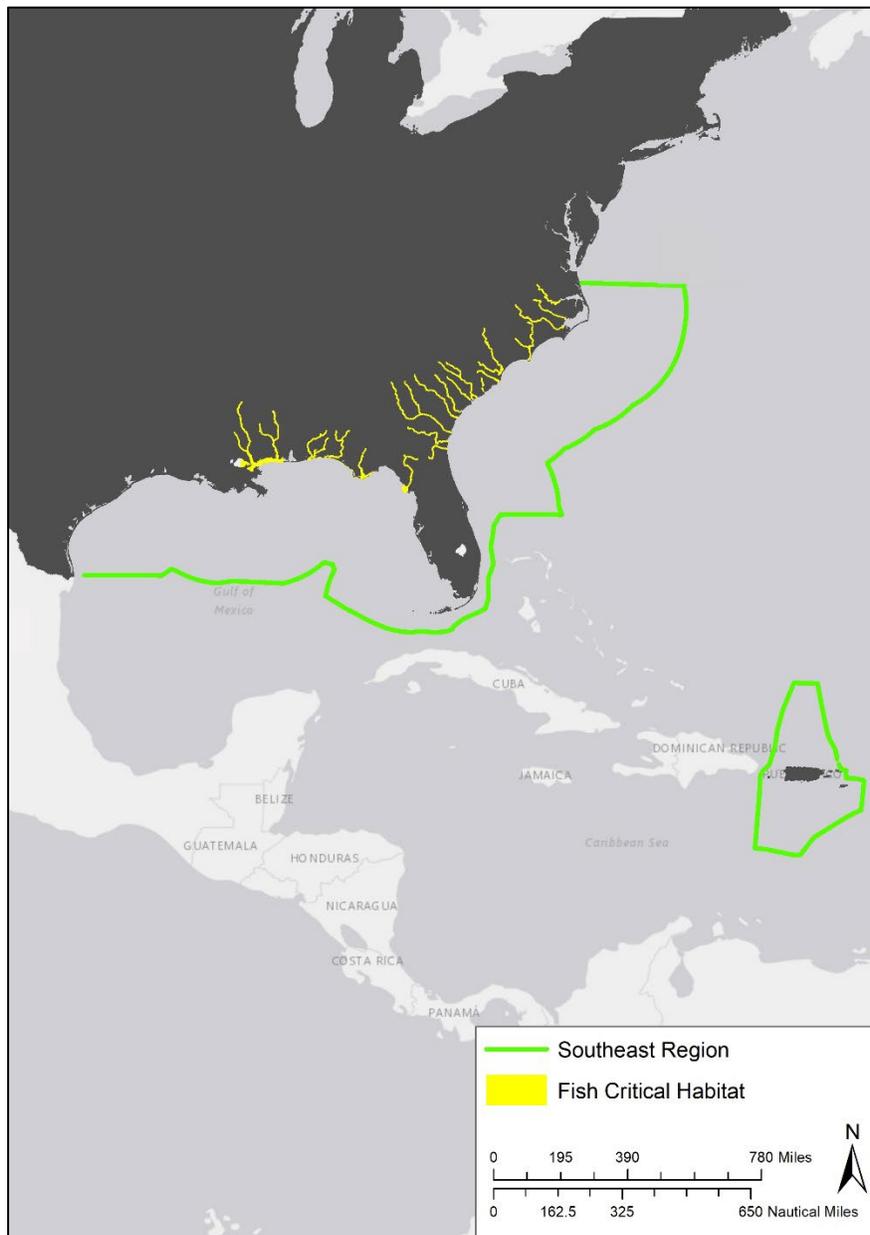


Sources: NMFS, No Date-b; ECOS, No Date-b

Figure 3.7-12. Designated Critical Habitat for Atlantic Sturgeon and Atlantic Salmon in the Greater Atlantic Region

3.7.1.5.2 Southeast Region

Nine ESA-listed fish (Nassau grouper, giant manta, scalloped hammerhead shark - Central and Southwest Atlantic DPS, largetooth sawfish, smalltooth sawfish, Atlantic sturgeon – Carolina DPS, Atlantic sturgeon – South Atlantic DPS, Atlantic sturgeon – Gulf or Mexico subspecies, and shortnose sturgeon) occur in the Southeast Region, as indicated in **Table 3.7-1**. The two DPSs of Atlantic sturgeon and the Atlantic sturgeon-Gulf of Mexico subspecies also have designated critical habitat in the region as shown in **Figure 3.7-13**, some of it occurring in inland rivers.

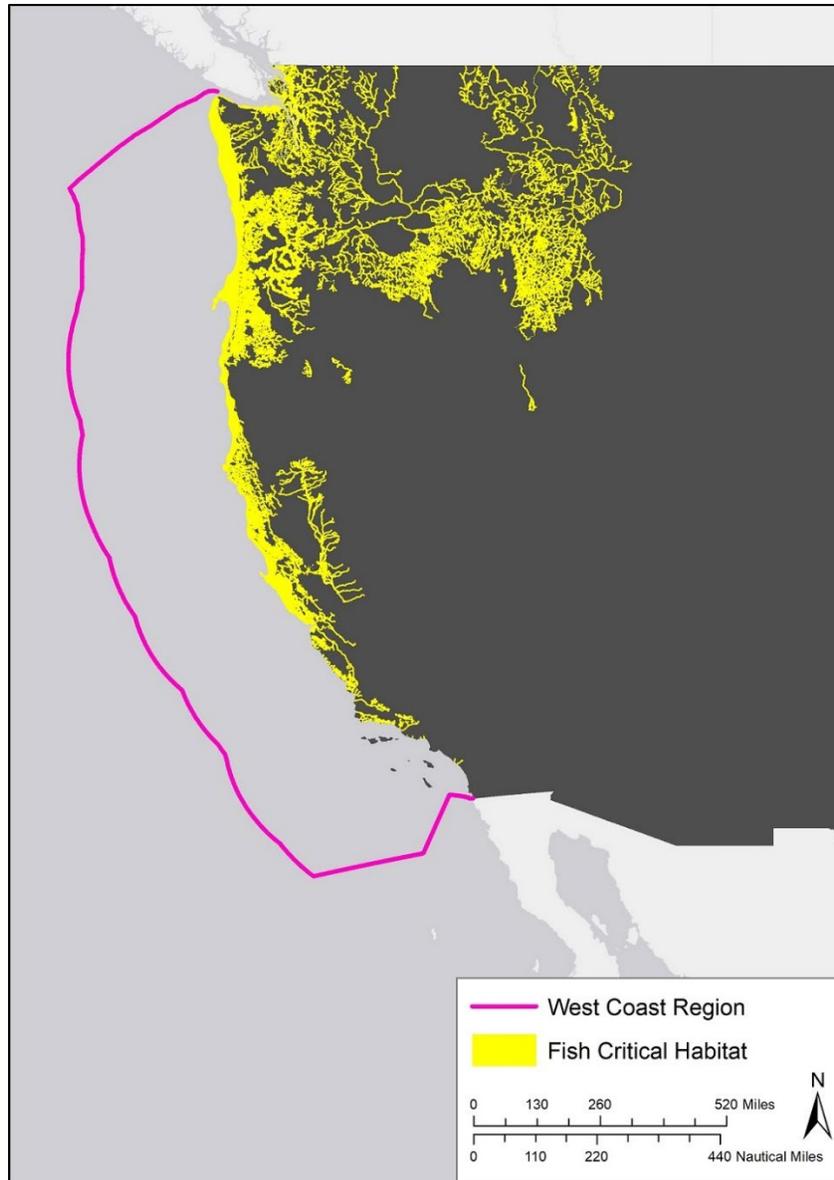


Sources: NMFS, No Date-b; ECOS, No Date-b

Figure 3.7-13. Designated Critical Habitat for Atlantic Sturgeon in the Southeast Region

3.7.1.5.3 West Coast Region

Thirty-six ESA-listed fish species, subspecies, ESU, or DPS occur in the West Coast Region, as indicated in **Table 3.7-1**. All nine ESUs of Chinook salmon, two ESUs of chum salmon, four ESUs of coho salmon, two ESUs of sockeye salmon, 11 DPSs of steelhead, tidewater goby, eulachon, yelloweye rockfish, bull trout, and green sturgeon have designated critical habitat in the region as shown in **Figure 3.7-14**, much of it occurring in inland rivers.



Sources: NMFS, No Date-b; ECOS, No Date-b

Figure 3.7-14. Designated Critical Habitat for Ten Fish Species in the West Coast Region

3.7.1.5.4 Alaska Region

Three ESA-listed fish (eulachon, bocaccio, and yellow rockfish) occur in the Alaska Region, as indicated in **Table 3.7-1**. None of these species have designated critical habitat in the region.

3.7.1.5.5 Pacific Islands Region

Three ESA-listed fish (giant manta, scalloped hammerhead [Eastern Pacific DPS], and scalloped hammerhead [Indo-West Pacific DPS]) occur in the Pacific Islands Region, as indicated in **Table 3.7-1**. None of these species have designated critical habitat in the region.

3.7.2 Environmental Consequences for Fish

This section discusses potential impacts of proposed activities associated with Alternatives A, B, and C on fish. ESA-listed endangered and threatened species are included as part of the discussion along with non-listed species because the potential impact mechanisms are the same. However, any impacts on managed species are of particular concern since they could affect key populations of these species. Effects determinations for ESA-listed species are presented at the end of this section after the analysis of impacts.

Activities described in Sections 2.4.1 through 2.4.13 that occur on NOS projects and that could be expected to impact fish include operation of crewed sea-going surface vessels; operation of ROVs and autonomous vehicles; use of echo sounders, ADCPs, acoustic communication systems, and sound speed data collection equipment; anchoring; collection of bottom grab samples; operation of drop/towed cameras and video systems; installation, maintenance, and removal of tide gauges and GPS reference stations; and SCUBA operations.

3.7.2.1 Methodology

The factors from NOS activities that could impact fish include: (1) active underwater acoustic sources (e.g., echo sounders, ADCPs, and acoustic communication systems); (2) vessel sound (e.g., from surface vessels, ROVs, and autonomous vehicles); (3) vessel surface wake and underwater turbulence (e.g., from surface vessels; ROVs and autonomous vehicles; survey equipment; and anchors); (4) accidental leakage or spillage of oil, fuel, and chemicals into surrounding waters (e.g., from vessel operations); (5) disturbance of the sea floor (e.g., from anchoring and bottom sampling); and (6) air emissions (e.g., from vessel smokestacks and outboard motors). These potential impact causing factors and their associated impacts on fish are discussed below for each alternative. Note that use of the term “sea floor” in the analysis below also includes lake and river bottoms where NOS activities could occur.

As discussed in Section 3.2.2, significance criteria were developed for each resource analyzed in this Final PEIS to provide a structured framework for assessing impacts from the alternatives and the significance of the impacts. The significance criteria for fish are shown in **Table 3.7-2**.

Table 3.7-2. Significance Criteria for the Analysis of Impacts to Fish

Impact Descriptor	Context and Intensity	Significance Conclusion
Negligible	Impacts to fish would be limited to temporary (lasting up to several hours) behavioral and stress-startle responses to individual fish or schools of fish found within the project area. Impacts on habitat would be temporary (e.g., placement of object on the sea floor which increases turbidity) with no lasting damage or alteration.	Insignificant
Minor	Impacts would be temporary or short-term (lasting several days to several weeks) but would not be outside the natural range of variability of species’ populations, their habitats, or the natural processes sustaining them. This could include temporary threshold shift of hearing or repeated, short-term stress responses without permanent physiological damage. Behavioral responses to disturbance by some individuals or a	

Impact Descriptor	Context and Intensity	Significance Conclusion
	<p>school of fish could be expected, but only temporary disturbance of breeding, feeding, or other activities would occur, without any impacts on population levels. Displacement would be short-term and limited to the project area or its immediate surroundings. Impacts on habitat would be easily recoverable (e.g., short-term placement of objects on the sea floor which increases turbidity or causes loss of a small area of vegetation) with no long-term or permanent damage or alteration.</p>	
<p>Moderate</p>	<p>Impacts would be short-term or long-term (lasting several months or longer) and outside the natural range of variability of species' populations, their habitats, or the natural processes sustaining them. This could include physiological injury to individuals in the form of temporary or permanent threshold shift, repeated stress responses, or mortality. Behavioral responses to disturbance by numerous individuals could be expected in the project area, its immediate surroundings, or beyond with some adverse impacts to breeding, feeding, growth, or other factors affecting population levels, including population-level mortality to, or extended displacement (up to a year) of large numbers (i.e., population-level) of fish but would not threaten the continued existence of a species. Habitat would be damaged or altered potentially over the long term but would continue to support the species reliant on it.</p>	
<p>Major</p>	<p>Impacts would be short-term or long-term and well outside the natural range of variability of species' populations, their habitats, or the natural processes sustaining them. Behavioral and stress responses would be repeated, and threshold shifts would be permanent. Actions would affect any stage of a species' life cycle (i.e., breeding, feeding, growth, and maturity), alter population structure, genetic diversity, or other demographic factors, and/or cause mortality beyond a small number of individuals, resulting in a decrease in population levels. Displacement and stress responses would be short- or long-term within and well beyond the project area. Habitat would be degraded over the long term or permanently so that it would no longer support a sustainable fishery and would cause the population of a managed species to become stressed, less productive, or unstable.</p>	<p>Significant</p>

3.7.2.2 **Alternative A: No Action - Conduct Surveys and Mapping for Coastal and Marine Data Collection with Current Technology and Methods, at Current Funding Levels**

Under Alternative A, NOS survey effort would cover a total of 2,647,958 nm (4,904,017 km) across all five regions over the five-year period. Although the survey effort under Alternative A would vary by year (see **Table 3.4-4**), over the five-year period for proposed projects that the greatest number of nautical miles surveyed would be in the Southeast Region (approximately 47 percent). The survey effort in each of the other four regions is approximately 10 percent over five years, and perhaps slightly greater in the Alaska Region where the survey effort would be somewhat higher overall (approximately 18 percent). Additionally, survey effort in the Great Lakes would average 2,917 nm (5,402 km) annually, as compared to the annual average survey effort of 529,592 nm (980,803 km) for the remainder of the action area. In general, it is expected that level of effort and overall impacts trend together (i.e., greater impacts where the survey effort is higher), but there are other factors, such as location and depth of surveys, hearing frequency of fish, and population densities of fish, that add nuance to this trend. Overall, NOS projects would be a very small part of all ocean activities as vessels used by NOS would represent a negligible proportion of all vessel traffic in the action area. Additionally, whenever possible, the location and timing of a given project would be purposefully coordinated to ensure that areas are not repeatedly surveyed. This ensures that the potential environmental impacts directly resulting from NOS projects and activities would not be exacerbated by repeated surveys within a given area.

3.7.2.2.1 **Fish**

The analysis of impacts on fish considers all of the impact causing factors introduced above, except for air emissions which are analyzed in Section 3.7.2.2.2. Potential impacts could occur in all of the geographic regions. All the regions include one or more ESA-listed species and designated critical habitat (with the exception that the Alaska Region and Pacific Islands Region do not have designated critical habitat). The West Coast Region contains the greatest number of ESA-listed species and the greatest amount of designated critical habitat (see **Table 3.7-1**).

In addition to the impacts on fish discussed in this section, fish may also be affected by alteration of habitat, such as degradation of water quality and disturbance of benthos, aquatic vegetation, and sediments. These impacts are discussed in Section 3.7.2.2.2 below.

3.7.2.2.1.1 **Active Underwater Acoustic Sources**

Effects of human-generated sound on fishes have been examined in numerous publications (Hastings and Popper, 2005; Hawkins et al., 2015; Mann, 2016; Neenan et al., 2016; Popper et al., 2003, 2007, 2014). Exposure of fish to sound from active underwater acoustic sources used in NOS projects, including echo sounders (0.5-900 kHz), ADCPs (35-1,200 kHz) and acoustic communication systems (10s of kHz), could affect pathological, physiological, and behavioral characteristics. As discussed in Section 3.7.1.3, the hearing frequency range of most fish is below approximately 1.5 kHz with the most sensitive range below 0.8 kHz. Thus, most fish may be able to hear low frequency sources that go down to 0.5 kHz, and which are used in deeper water, but remain outside of the primary energy band. The hearing range of pressure-sensing fish is typically extended to a few kHz (up to about 4 kHz). However, at least three species of herring-like fishes detect sounds above 20 kHz (Mann et al., 1997). Generally, underwater acoustic sources have not been known to cause direct injury or mortality to fish under conditions that would be found in the wild (Halvorsen et al., 2012; Kane et al., 2010; Popper et al., 2007). Potential direct injuries (e.g., barotrauma, hemorrhage or rupture of organs or tissue) from such sound sources are unlikely because of slow rise times (the amount of time for a signal to change from static pressure [the ambient pressure

without the added sound] to high pressure), lack of strong shock waves, and relatively low peak pressures (Navy, 2018a).

Exposure to high-intensity sound can cause hearing loss, also known as a noise-induced threshold shift. TTS) is a temporary, recoverable loss of hearing sensitivity which 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 (including multiple exposures). 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 cells loss is permanent (Lombarte et al., 1993; Popper et al., 2014; Smith et al., 2006). As a consequence, PTS has not been known to occur in fish, and any hearing loss in fish may be temporary (i.e., for as long as required to repair or replace the damaged or destroyed cells) (Popper et al., 2005; Popper et al., 2014; Smith et al., 2006). For both TTS and PTS, the fish does not become deaf but requires a louder sound stimulus to detect a sound within the affected frequencies.

All fish detect and use particle motion, particularly at frequencies below several hundred Hz (Popper and Hawkins, 2019). Thus, the detection of particle motion is integral to hearing in all fishes (and invertebrates), and it is used to locate the direction of the source, even in those fishes that are also sensitive to sound pressure. Some fish species with a swim bladder that is involved in hearing may be more susceptible to TTS from high intensity sound sources, such as echo sounders, depending on the duration and frequency of the exposure (Popper et al., 2014). 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. 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 higher frequency sonars and would likely require a much higher source level to exhibit the same effect from exposure to low-frequency active sonar. Adverse effects are possible for the small numbers of individual fish that could occur in close proximity (i.e., within several meters) to an active sound source. Generally, adverse effects on a species can be considered significant if they result in a reduction in the overall health and viability of a population. However, given the localized and transient spatial scale of no more than a few NOS projects occurring at any one time, relative to the generally large-scale distribution of fish populations and the considerably narrow beam characteristics of equipment such as echo sounders, no population level effects are expected on marine or freshwater fish.

Behavioral effects from active underwater acoustic sources include changes in the distribution, migration, and breeding of fish populations. Fish typically exhibit a sharp startle response at the onset of a sound, followed by habituation and a return to normal behavior after the sound ceases (Boeger et al., 2006; Wardle et al., 2001). The behavior and ecology of fish whose hearing does not overlap with the emitted sounds of active underwater acoustic sources would not, in most cases, be expected to be affected. A possible exception would be that those individuals within several meters of a sound source operating at high levels could be harmed by the energy of the sound, though the intensity of the impact is unknown. The frequencies of echo sounders, ADCPs, and acoustic communication systems do not overlap with the frequencies at which most marine and freshwater fish, including ESA-listed fish, are known to detect or produce sound (see above and Section 3.7.1.3). An exception to this is that some of the herring-like fishes (of the Clupeoid subfamily Alosinae: the anadromous shads, river herrings, and near-shore menhadens) can detect very high frequency (>20 kHz) signals (Mann et al., 2001). Non-alosine Clupeoids (sea herrings, sardines, and anchovies, among other marine fish species) do not hear above 4 or 5 kHz (Mann et al., 2001). For those fishes in the Alosine subfamily of herrings that can hear at frequencies above 20 kHz,

exposures of most individual fish would be very brief. Therefore, NOS active underwater acoustic sources are very unlikely to result in population-level effects on these fish species.

Masking is the effect of an acoustic source interfering with the reception and detection of an acoustic signal of biological importance to a receiver (NSF and USGS, 2011). Any sound within an animal's hearing range can mask relevant sounds. Active underwater acoustic sources and vessel sound (see section below) could contribute to localized transitory masking of sound detection by some fish, at least those species mentioned above whose sound detection capacities are in the frequency range of the active sound sources. However, in general, the potential for masking effects would be limited given the brief, pulsed nature of the equipment and the transiting vessels used by NOS relative to individual fish. For alosine herrings, there could be some disturbance from underwater sound, such as changes in swim direction, speed, foraging patterns, and respiration patterns; however, the temporal and spatial scale of these effects would be short-term and localized to the area where the sound is being emitted. For most fish populations, including ESA-listed species, disturbance from active underwater acoustic sources would be limited to any relatively small portion of a population that may be located near the active sound source. Such effects would be considered insignificant at the population level.

NOS projects using active underwater acoustic sources would likely cross schools or aggregations of fish. Depending on water depth, these would include coastal pelagic, epipelagic, and demersal hard bottom species. If encountered, interactions with fish would be temporary because the vessel used by NOS would be constantly moving during project activities. Species exposed to sound might move away from the sound source; experience short-term TTS (hearing loss), masking of biologically relevant sounds, or increased levels of stress hormones; or may not show obvious effects (BOEM, 2014a). Mortality is very unlikely. Sound levels would return to ambient conditions once the sound source ceases. When exposure to sound ends, stress-related behavioral response by fishes would also be expected to end (McCauley et al., 2000b).

For fish species, the greatest potential for adverse impacts as a result of active underwater acoustic sources under Alternative A would be related to changes in behavior. Of primary importance is any change in behavior that would increase mortality or result in reduced survival or reproductive success. To be significantly adverse, such behavioral changes would need to cause an overall reduction in population abundance. Sound detection by the majority of marine and freshwater fishes, and hence behavioral disturbance and hearing impairment, is unlikely to occur due to the much higher frequencies of the NOS acoustic sources relative to fish hearing capabilities, although these sources could affect the behavior of shad, herrings and other fish that can hear these sounds. Active underwater acoustic sources would have the potential to disrupt spawning aggregations or schools of fishes, including those important as prey for other fishes and marine mammals. However, the mobile and temporary nature of the NOS projects, as well as the small area of the sea floor affected during the projects relative to the entire action area, and the potential for fish to temporarily move away from sound that is affecting them, would result in overall **adverse** and **minor** impacts. Impacts on fish, including ESA-listed species, would be **insignificant**.

3.7.2.2.1.2 Vessel Sound

All vessels produce underwater sound (in the 0.01 to 10 kHz frequency range) and are major contributors to overall background sound in the sea (see Appendix E). Source levels and frequency characteristics are roughly related to ship size and speed. The dominant sound source of vessels used by NOS is propeller cavitation, although propeller singing, propulsion machinery, and other sources (e.g., flow noise, wake bubbles) can also contribute to underwater sound. It is likely that fish occurring in locations where there is high vessel traffic have habituated to this sound. Sounds from vessels are generally below levels that can cause temporary hearing loss or injury in fish. Underwater vessel sound can disturb and displace

nearby fish, interrupt feeding, cause other behavior modifications, and possibly mask biologically important signals; such impacts would vary among species as most fish cannot hear the higher frequencies emitted by vessel sound, except for perhaps shads, river herrings, and menhadens (see discussion in Sections 3.7.1.3 and 3.7.2.2.1.1). Impacts on fish behavior are expected to be temporary and localized to areas of vessel activity.

ROVs also generate engine sound, and impacts on fish would be similar to those from sound from surface vessels, but likely at a reduced severity as ROVs are smaller, thus producing less sound, and they would not be used as extensively as surface vessels (see **Table 2.6-1**).

In remote areas that are reached by boat for tide gauge installation, maintenance, and removal, impacts on fish could occur and would be similar to those from surface vessel operations. Likewise, installation of a shore-based GPS reference station would not have any effects on fish other than potentially from accessing the site via a surface vessel, in which case impacts on fish could occur and would be similar to those from surface vessel operations.

Vessels used by NOS would represent only a negligible proportion of total vessel traffic in the action area. Based on the proposed amount of vessel traffic associated with NOS projects in the action area under Alternative A, and the relatively low amounts of vessel sound produced as compared to sound from all other marine traffic in U.S. waters, the overall effects of vessel sound on fish, including ESA-listed species, would continue to be **adverse** and **negligible** as impacts would be limited to temporary behavioral and stress-startle responses to individual fish or schools of fish found within the project area. The severity of effects on shads, river herrings, and menhadens, species that can potentially hear the higher frequencies of vessel sound, could be somewhat higher but are not expected to be more than **minor**, as impacts under Alternative A would still continue to be temporary or short-term, may include some stress responses without permanent physiological damage, and may disturb breeding, feeding, or other activities but without any impacts on population levels. Any displacement of fish would continue to be short-term and limited to the NOS project area or its immediate surroundings. Thus, impacts under Alternative A would continue to be **insignificant**.

3.7.2.2.1.3 *Vessel Wake and Underwater Turbulence*

Water disturbance by surface vessel and ROV wakes and underwater turbulence could temporarily disturb and displace nearby fish in the project area or in a portion of the project area. The impact on fish would be minimal as the vessel would quickly pass by or stop moving. In any case, fish are expected to return to the area and resume normal activities once the vessel departs or the ROV is no longer present. The impact from ROVs would also be minimal; they would not create a wake or much underwater turbulence because they are slow-moving and relatively small.

Equipment used in NOS projects, such as echo sounders and ADCPs, are typically attached to a crewed vessel, ROV, or autonomous vehicles; thus, effects on fish due to water movement that is created would occur from the use of these carriers, rather than any disturbance from the equipment itself. An exception would be in the rare instances when echo sounders are placed directly on the sea floor or operated by divers, who would move through the water column, possibly disturbing fish temporarily.

Some equipment, such as sound speed data collection equipment, bottom grab samplers, and drop/towed cameras, is lowered and raised through the water column or falls through the water. This movement through the water could temporarily disturb and displace nearby fish, although fish would not

be expected to move too far. These impacts would be temporary as fish are expected to return once water column turbulence ceases.

Under Alternative A, effects on fish, including ESA-listed species, from vessel wake and underwater turbulence would continue to be **adverse** and **negligible** as responses to disturbance by some individuals would be limited to temporary behavioral and stress-startle responses, but without interference to factors affecting population levels. Thus, impacts under Alternative A would continue to be **insignificant**.

3.7.2.2.1.4 Accidental Leakage or Spillage of Oil, Fuel, and Chemicals

An accidental event could result in release of oil, fuel, or chemicals by a vessel used by NOS in a project area and its immediate surroundings. Adverse impacts on fish could also occur from pumping of oily bilge water overboard, discharged wastewater/graywater that may contain nutrients and fecal coliform bacteria, and accidental oil, fuel, and chemical spills. Most adult fish are mobile enough to avoid discrete, limited areas of higher concentrations of oil and other contaminants. Depending on the product, most oil would remain at or near the surface and typically would not impact fish in deeper water. Lighter substances can disperse into the water column or might dissolve in water, potentially impacting eggs, larvae, and juvenile fish which are more susceptible than adults since they are less mobile. Coastal pelagic and epipelagic species that forage at the surface would be most likely to encounter a spill (BOEM, 2014a).

Although the probability of accidental oil and chemical spills is very low, if exposed, fish can be affected directly either by ingestion of oil products or oiled prey, through uptake of dissolved petroleum compounds and through effects on fish eggs and larvae survival (Malins and Hodgins, 1981). Sublethal effects may cause stress and may be transient and only slightly debilitating, but fish may also be killed when coming into contact with oil and other contaminants. Repair and recovery require metabolic energy, and use of this energy may ultimately lead to increased vulnerability to disease or to decreased growth and reproductive success. The egg, early embryonic, and larval-to-juvenile stages of fish seem to be the most sensitive to oil products. The lethal effects may not be realized until the fish fails to hatch, dies upon hatching, or exhibits some abnormality as a larva, such as an inability to swim.

Fish can be affected indirectly by oil, spilled fuel, and chemicals through changes in the ecosystem that affect prey species and habitats. All fish rely on phytoplankton and zooplankton during their larval and juvenile stages. However, even if a large amount of plankton were affected, it can recover rapidly due to high reproductive rates, rapid replacement by cells from adjacent waters, widespread distribution, and exchange with tidal currents. Thus, the impact on a pelagic phytoplankton community, and on fish, would not be substantial.

Such accidents may be caused by equipment malfunction, human error, or natural phenomena and are not expected during the course of NOS operations. In the unlikely event of an accidental spill, there would be very low likelihood for contaminants to make contact with the water because vessel operations personnel are required to respond immediately using established spill response procedures. For example, on NOAA fleet vessels, in the event of an oil, hazardous substance, or marine pollutant spill, the Commanding Officer takes appropriate action to minimize the effects of the spill. OMAO Procedure 0701-06 VRP/SOPEP provides policy and guidance to all NOAA vessels regarding oil pollution emergency planning and response, in accordance with MARPOL 73/78, Annex I. The plan contains all the information and instruction required for responding to shipboard oil spills, such as general spill mitigation and response, shipboard spill mitigation and response, reporting requirements, completing Corrective Action Assessments, trainings, drills, and exercises. This plan has been approved by the USCG, and complies with the Oil Pollution Act of 1990 and Federal Water Pollution Act of 1973.

Under Alternative A, the likelihood of an accidental spill from a vessel used by NOS would continue to be very low, thus impacts are expected to be **adverse** and **negligible**. All hazardous or regulated materials would be handled in accordance with applicable laws, crew members would be appropriately trained in materials storage and usage, and all MARPOL discharge protocols would be followed. In the event that an accidental spill does occur, the volume of oil, fuel, and/or chemicals would be fairly small given the amounts of fuel and other chemicals that vessels used by NOS typically carry for onboard consumption; thus, the impact on fish would continue to be **adverse** and **minor** as impacts would be temporary or short-term without any impacts on population levels. Displacement of fish that move away to avoid spilled substances would continue to be short-term and limited to the project area or its immediate surroundings. Impacts on fish, including ESA-listed species, would be considered **insignificant**.

3.7.2.2.1.5 *Disturbance of the Sea Floor*

Anchoring is an infrequent activity and would only occur in a small portion of a project area (see **Table 2.6-1**). Water disturbance by anchors and chains moving in the water and across the sea floor can temporarily disturb and displace nearby fish. This impact on fish would be negligible and cease with the anchoring system coming to rest or being taken out of the water. Any displaced fish are expected to return to the area and resume normal activities once water column turbulence ceases.

If anchor chains drag across the sea floor, they can create a circular scour hole (Limpinsel et al., 2017). Anchor scour has the potential to create localized turbidity that could reduce water clarity and increase sediment deposition. Increased turbidity and sedimentation can have minor impacts on juvenile and adult fish by reducing feeding efficiency, altering reproductive cycles, and reducing response to physical stimulus. In cases where organisms are exposed to excessive turbidity, the sediments can coat gills, thus limiting gas exchange and possibly leading to asphyxiation. However, adult fish are mobile and can avoid highly turbid areas and, under most conditions, can survive short exposure (minutes to hours) to elevated turbidity levels. Additionally, NOS would not drag anchor chains and would ensure that anchors are properly secured so as to minimize bottom disturbance.

More sensitive species and life stages (i.e., eggs, larvae, and fry) are impacted by longer exposure to suspended (or deposited) sediments than less sensitive species and older life stages. There could be delayed or reduced hatching of eggs, reduced larval growth or development, and abnormal larval development. There would not be any direct impacts on those fish that spawn in coral reefs as vessels would not anchor on coral reefs. Coral reef fish spawn in the water column, though, and release planktonic eggs which drift away with the currents, hatch to larvae, and develop in the water column; thus, there could be impacts from suspended sediments. However, suspended sediments are expected to settle quickly and long exposures are not likely to occur.

Collecting bottom samples could create localized turbidity and affect soft-bottomed seafloor habitat, potentially creating turbidity that could reduce water clarity temporarily. Such turbidity would likely be minimal as samplers are designed to close to contain the sediment and prevent sample washout. In some instances, equipment, such as echo sounders and XBTs, may be placed directly on the sea floor and could also cause minimal temporary localized turbidity. Fish in the vicinity could likely swim away and avoid any of these turbidity impacts. NOS would ensure that all instruments placed in contact with the sea floor are properly secured so as to minimize bottom disturbance. Additionally, equipment such as Autonomous Underwater Vehicles (AUVs) would be programmed and operated so as to avoid seafloor disturbance, SCUBA divers would avoid inadvertent disturbance to the sea floor, and stiffer line material would be used

and kept taut during operations to reduce potential for entanglement with bottom features such as coral habitat.

Effects on fish from disturbance of the sea floor under Alternative A would continue to be **adverse** and **negligible** to **minor**. Impacts to fish would continue to be temporary behavioral responses to localized turbidity by some individuals, including potential disturbance of breeding, feeding, or other activities but without any impacts on population levels. Displacement would continue to be temporary and limited to the project area. Impacts on fish, including ESA-listed species, would continue to be **insignificant**.

3.7.2.2.2 Fish Habitat

The analysis of impacts on fish habitat, including designated critical habitat, does not consider active underwater acoustic sources or vessel and equipment sound as these impact causing factors would not affect habitat characteristics (other than on prey fish, which would have similar impacts as described above for fish in general).

3.7.2.2.2.1 Vessel Wake and Underwater Turbulence

Vessel wakes and turbulence can generate wave and surge effects on nearby shorelines and stir up bottom sediments in shallow locations of a project area and its immediate surroundings depending on the wake wave energy, the water depth, and the type of shoreline (Limpinsel et al., 2017). Vessel wakes can cause shoreline erosion, degrade wetland habitat, and increase water turbidity. Water column habitat gradients would be temporarily disrupted by wake action, including temperature, salinity, DO, turbidity, and nutrient supply. Stirring up lake sediment can re-suspend nutrients such as phosphorus, potentially contributing to harmful, DO-consuming algal blooms. Impacts would have greater effects in habitats where fish aggregate, such as spawning aggregation sites, feeding areas, hard bottom habitats, and artificial reefs, than in locations with few fish. Also, not only would these types of impacts occur in general fish habitat, but also such areas as nearshore marine critical habitat, for such species as bull trout and bocaccio, and estuarine critical habitat, for such species as Atlantic salmon, gulf sturgeon, and green sturgeon. To reduce these adverse effects of wake action which may occur in a project area and its immediate surroundings, vessels used by NOS would operate at sufficiently low speeds (up to 10 knots) to reduce wake energy when in shallow areas or close to shorelines. Additionally, all vessels in coastal waters would operate in a manner to minimize propeller wash, and transiting vessels should follow deep-water routes (e.g., marked channels), as practicable, to reduce disturbance to sturgeon and sawfish critical habitat.

The suspension of disturbed sediments from wake action and shoreline erosion could minimize the light intensity that reaches aquatic vegetation which depends on light for photosynthesis. High turbidity that causes a substantial reduction in light availability can lead to sublethal adverse effects or mortality of aquatic vegetation. Suspended material may also react with DO in the water and result in temporary or short-term oxygen depletion to aquatic resources, including vegetation and aquatic macroinvertebrates.

The movement of AUVs, equipment used in projects such as sound speed data collection equipment, bottom grab samplers, drop/towed cameras, and anchors and chains through the water column could temporarily cause turbulence and disturb nearby aquatic macroinvertebrates and other prey species, as well as potentially cause damage to submerged aquatic vegetation. These impacts would be temporary as benthos and prey species are expected to return once water column turbulence ceases.

Equipment such as echo sounders, ADCPs, and acoustic communication systems are typically attached to a crewed vessel, ROV, or autonomous vehicles, thus effects on habitat would occur from the use of these

carriers, rather than any disturbance from the acoustic equipment itself. One exception would be in the rare instances when echo sounders are placed directly on the sea floor or operated by divers. In such cases, divers would move through the water column temporarily disturbing benthic communities and prey species. Lines connecting equipment to a vessel could also become entangled with, damage, or kill aquatic vegetation such as seagrass.

Underwater turbulence could occur during tide gauge installation even though it occurs primarily out of the water at existing piers, docks, bulkheads, and other such locales. All buoys would be attached to the sea floor using the best available mooring systems to reduce entanglement. Generally, no impact on habitat would occur except when tide gauge installation requires in-water work that could cause sediment disturbance. In remote areas which are reached by boat for installation, maintenance, and removal, impacts on habitat could occur and would be similar to those for surface vessel operations. Likewise, installation of a shore-based GPS reference station would not have any effects on habitat other than potentially from accessing the site via a surface vessel, in which case impacts on prey fish could occur and would be similar to those from surface vessel operations.

Effects on habitat, including designated critical habitat, from vessel wake and underwater turbulence under Alternative A would continue to be **adverse** and **minor** as habitat impacts would be easily recoverable with no long-term damage or alteration. Thus, impacts under Alternative A would continue to be **insignificant**.

3.7.2.2.2 Accidental Leakage or Spillage of Oil, Fuel, and Chemicals

An accidental event could result in release of oil, fuel, or chemicals by a vessel used by NOS in a project area and its immediate surroundings. The accidental loss of a substantial amount of fuel or lubricating oil during projects could affect water quality, the water column, the sea floor, intertidal habitats, and associated biota (i.e., aquatic macroinvertebrates and submerged aquatic vegetation) resulting in their mortality or substantial injury, and in alteration of the existing quality of fish habitat. Habitat most at risk from a small spill would be pelagic Sargassum as it drifts at the surface in windrows or mats, and supports numerous fish and invertebrates (BOEM, 2014a).

Vessel bilge water discharges, engine operations, bottom paint sloughing, boat washdowns, and other vessel activities or wear can also deliver debris, nutrients, and contaminants to waterways which may degrade water quality, contaminate sediments, and alter benthic communities in fish habitat. Vessel wash, including gray water, deck runoff and cooling water can damage aquatic vegetation and disturb benthos and sediments, which may increase turbidity and suspend contaminants in habitat. Any liquid contaminants, however, are expected to be rapidly diluted throughout the water column.

Impacts from an accidental fuel spill and release of other contaminants would not only occur in general fish habitat, but also such areas as nearshore marine critical habitat, for such species as bull trout and bocaccio, deepwater critical habitat, for bocaccio and yelloweye rockfish, and estuarine critical habitat, for such species as Atlantic salmon, gulf sturgeon, and green sturgeon. It is also possible that impacts on critical habitat in rivers and streams for many species of salmon and steelhead could occur if vessels used by NOS are working in freshwater habitat.

Such accidents may be caused by equipment malfunction, human error, or natural phenomena and are not expected during the course of NOS operations. In the unlikely event of an accidental spill, there would be very low likelihood for contaminants to make contact with the water because vessel operations personnel are required to respond immediately using established spill response procedures. For example,

on NOAA fleet vessels, in the event of an oil, hazardous substance, or marine pollutant spill, the Commanding Officer takes appropriate action to minimize the effects of the spill. OMAO Procedure 0701-06 VRP/SOPEP provides policy and guidance to all NOAA vessels regarding oil pollution emergency planning and response, in accordance with MARPOL 73/78, Annex I. The plan contains all the information and instruction required for responding to shipboard oil spills, such as general spill mitigation and response, shipboard spill mitigation and response, reporting requirements, completing Corrective Action Assessments, trainings, drills, and exercises. This plan has been approved by the USCG, and complies with the Oil Pollution Act of 1990 and Federal Water Pollution Act of 1973.

All hazardous or regulated materials would be handled in accordance with applicable laws, all MARPOL discharge protocols would be followed, and crew members would be appropriately trained in materials storage and usage. The likelihood of occurrence of an accidental spill from a vessel used by NOS would be very low, although the release of other contaminants is a little more likely; thus, impacts are expected to be **adverse** and **negligible**. In the event that an accidental spill does occur, the volume of oil, fuel, and/or chemicals would be fairly small given the amounts of fuel and other chemicals that vessels used by NOS typically carry for onboard consumption; thus, the impact on habitat would be **adverse** and **minor** as habitat impacts would be easily recoverable with no long-term damage or alteration. Impacts on habitat, including designated critical habitat, would be considered **insignificant**.

3.7.2.2.2.3 *Disturbance of the Sea Floor*

Adverse impacts on fish habitat can occur when vessels anchor in shallow nearshore waters and the anchor chain drags across the sea floor, destroying submerged vegetation and creating a circular scour hole. Anchor scour has the potential to create localized turbidity and affect soft-bottomed seafloor habitat and/or rocky substrates, potentially creating turbidity that could reduce water clarity and increase sediment deposition. NOS would not drag anchor chains and would ensure that anchors are properly secured so as to minimize bottom disturbance.

Increased turbidity immediately following anchoring events could temporarily reduce foraging ability of prey due to decreased visibility in the water column; however, impacts to these conditions would be minor and of short duration and would soon return to baseline. Suspended material may also react with DO in the water and result in temporary oxygen depletion to aquatic resources.

Collecting bottom samples could create localized turbidity and affect soft-bottomed seafloor habitat, potentially creating turbidity that could reduce water clarity temporarily. Such turbidity would likely be minimal as samplers are designed to close to contain the sediment and prevent sample washout. Likewise, placement of echo sounders on the sea floor has the potential to create localized turbidity that could reduce water clarity temporarily, although this would be minor. NOS would not collect bottom samples on known coral reefs and would ensure that all instruments placed in contact with the sea floor are properly secured so as to minimize bottom disturbance. Additionally, equipment such as AUVs would be programmed and operated so as to avoid seafloor disturbance, SCUBA divers would avoid inadvertent disturbance to the sea floor; and stiffer line material would be used and kept taut during operations to reduce potential for entanglement with bottom features such as coral habitat.

Similar impacts from disturbance of ocean or river bottom could also occur in designated critical habitat if anchoring, collection or bottom samples, or placement of equipment occurs in such locations, including nearshore marine designated critical habitat of bull trout and bocaccio, estuarine critical habitat of Atlantic salmon, gulf sturgeon, and green sturgeon, and riverine critical habitat of species of salmon and steelhead. Additionally, all vessels in coastal waters would operate in a manner to minimize seafloor

disturbance, and transiting vessels should follow deep-water routes (e.g., marked channels), as practicable, to reduce disturbance to sturgeon and sawfish critical habitat.

Effects from disturbance of the sea floor would be **adverse** and **negligible to minor** as habitat impacts would be easily recoverable with no long-term damage or alteration. Impacts on habitat, including designated critical habitat, would be **insignificant**.

3.7.2.2.4 Air Emissions

Since the pre-industrial era, increased emissions of anthropogenic GHGs (e.g., CO₂, CH₄, and N₂O) have resulted in higher atmospheric concentrations of these gases that influenced changes in oceanic conditions (as well as atmospheric and terrestrial conditions) (Limpinsel et al., 2017). Higher atmospheric CO₂ levels increase dissolved CO₂ and bicarbonate ions in seawater, which subsequently leads to a decrease in seawater pH and carbonate ions. In general, a decrease in pH corresponds to a simultaneous increase in acidity, termed “ocean acidification.” Changes in seawater carbon chemistry, in particular interference with the formation of CaCO₃ in marine shells and skeletons, may adversely affect marine biota through a variety of biochemical, physiological, and physical processes and interactions.

Smokestack and two-stroke outboard motor emissions from vessels used by NOS would release air pollutants, which can be deposited on the water surface and contribute to adverse effects such as increasing water acidity in fish habitat, including designated critical habitat. In addition, two-stroke outboard motors can emit 25-30 percent of their unburned gas and oil mixture directly into the water, adding metals and chemicals directly to the water column. The amount of emissions from vessels used by NOS would be negligible compared to emissions from all other vessel activity in the oceans. Thus, impacts from air emissions are expected to be **adverse** and **minor** since air emissions could travel and be deposited within the project area. Air emissions could be deposited immediately outside of the project area but would dissipate fairly quickly. Impacts on habitat, including designated critical habitat, would be **insignificant**.

3.7.2.2.3 Conclusion

Under Alternative A, NOS would continue to operate a variety of equipment and technologies to gather data on the marine and coastal environments at the level of effort reflecting NOS fiscal year 2019 funding levels. Since the effects of impact causing factors on fish and fish habitat range from negligible to minor, the overall impact of Alternative A on fish, including ESA-listed species and designated critical habitat, would continue to be **adverse** and **minor**; thus, impacts of Alternative A would be **insignificant**.

3.7.2.3 Alternative B: Conduct Surveys and Mapping for Coastal and Marine Data Collection with Equipment Upgrades, Improved Hydroacoustic Devices, and New Tide Stations

The same impact causing factors for fish and fish habitat considered under Alternative A are considered under Alternative B. Under Alternative B, all of the activities and equipment operations proposed in Alternative A would continue but at a higher level of effort, although the percentage of nautical miles covered by project activities in each region would be the same as under Alternative A. Thus, the greatest level of effort would be in the Southeast Region (with approximately 47 percent of the survey effort); level of effort in the other four regions would be at similar levels (approximately 10 percent of the survey effort in each region), and perhaps slightly greater in the Alaska Region where the survey effort would be somewhat higher overall (approximately 18 percent). The level of effort in the Great Lakes would remain much lower as compared to an annual total marine survey effort. In general, it is expected that level of

effort and overall impacts trend together (i.e., greater impacts where the survey effort is higher), but there are other factors, such as location and depth of surveys, hearing frequency of fish, and population densities of fish, that add nuance to this trend.

Projects under Alternative B would take place in the same geographic areas and timeframes as under Alternative A; however, Alternative B would include more projects and activities, and thus more nautical miles traveled, than Alternative A. Under Alternative B, NOS survey effort would cover a total of 2,912,753 nm (5,394,419 km) across all five regions over the five-year period. Overall, survey effort would cover an additional 264,796 nm (490,402 km) under Alternative B (see **Table 3.4-5**) as compared to Alternative A (2,647,958 nm [4,904,017 km] total) across all regions over the five-year period. The types and mechanisms of impacts would remain the same in Alternative B as discussed for Alternative A. Therefore, the difference between the two alternatives is a matter of scale with an increased activity level, although distributed unevenly among the different types of activities, leading to a corresponding, incremental increase in effects under Alternative B as compared to Alternative A.

For example, under Alternative B there would be projects using crewed vessel operations covering 577,000 nm (1,070,000 km), as compared to 518,000 nm (959,000 km) under Alternative A. Vessel operations could contribute to impacts on fish and fish habitat related to vessel sound, vessel wake and underwater turbulence, accidental spills, and air emissions. Although the amount of crewed vessel operations would be greater under Alternative B than under Alternative A, additional projects covering 59,000 nm (111,000 km) across five regions would result in greater impacts overall, but not so great that the magnitude of a particular impact causing factor would increase (e.g., from negligible to minor). The magnitude of impacts would likewise remain the same for other proposed activities contributing to potential impacts, such as underwater sound from echo sounders, ADCPs, and acoustic communication systems; and bottom disturbance from anchoring, bottom grab samples, and sound speed data collection.

Although NOS would add more widespread adoption of new techniques, protocols, and technologies to more efficiently perform surveying, mapping, charting, and related data gathering under Alternative B as compared to Alternative A, impacts on fish, including ESA-listed species, and fish habitat, including designated critical habitat, would be the same or slightly, but not appreciably, larger than those discussed above under Alternative A for each impact causing factor. Overall, impacts of Alternative B on fish would be **adverse, minor, and insignificant**.

3.7.2.4 Alternative C: Upgrades and Improvements with Greater Funding Support

The same impact causing factors for fish and fish habitat considered under Alternatives A and B are considered under Alternative C. Under Alternative C, all of the activities and equipment operation proposed in Alternative A would continue but at a higher level of effort, although the percentage of nautical miles in each region would be the same as under Alternatives A and B. In addition, there would be an overall funding increase of 20 percent relative to Alternative B, thus the level of project activity would increase further. Thus, the level of effort would be in the Southeast Region (with approximately 47 percent of the survey effort); level of effort in the other four regions would be at similar levels (approximately 10 percent of the survey effort in each region), and perhaps slightly greater in the Alaska Region where the survey effort would be somewhat higher overall (approximately 18 percent). The level of effort in the Great Lakes would remain much lower as compared to an annual total marine survey effort. In general, it is expected that level of effort and overall impacts trend together (i.e., greater impacts where the survey effort is higher), but there are other factors, such as location and depth of surveys, hearing frequency of fish, and population densities of fish, that add nuance to this trend.

Projects under Alternative C would take place in the same geographic areas and timeframes as under Alternatives A and B; however, Alternative C would include more projects and activities, and thus more nautical miles traveled, than Alternatives A and B. Under Alternative C, NOS survey effort would cover a total of 3,177,549 nm (5,884,821 km) across all five regions over the five-year period. Overall, there would be an additional 264,796 nm (490,402 km) covered by vessels used by NOS under Alternative C (see **Table 3.4-6**) as compared to Alternative B (2,912,753 nm [5,394,419 km] total), and an additional 529,592 nm (980,803 km) as compared to Alternative A (2,647,958 nm [4,904,017 km] total) across all regions over the five-year period. The types and mechanisms of impacts would remain the same in Alternative C as discussed for Alternatives A and B across all regions over the five-year period. Therefore, the difference between the alternatives is a matter of scale with an increased activity level, although distributed unevenly among the different types of activities, leading to a corresponding, incremental increase in effects under Alternative C as compared to Alternatives A and B. As discussed under Alternative B, the additional projects and nautical miles traveled under Alternative C across five regions would result in greater impacts on fish overall, but not so great that the magnitude of a particular impact causing factor would increase (e.g., from negligible to minor).

Alternative C would be similar to Alternative B, plus it would consist of NOS program implementation with an overall funding increase of 20 percent relative to Alternative B. However, impacts of Alternative C on fish, including ESA-listed species, and fish habitat, including designated critical habitat, would be the same or slightly, but not appreciably, larger than those discussed above under Alternatives A and B for each impact causing factor. Overall, impacts of Alternative C on fish would be **adverse, minor, and insignificant**.

3.7.2.5 Endangered Species Act Effects Determination

Federal agencies are required under the ESA to formally determine whether their actions may affect listed species or their designated critical habitat. Effects determinations divide potential effects into three categories: No Effect; May Affect, but Not Likely to Adversely Affect; and May Affect, and is Likely to Adversely Affect. Actions receiving a “No Effect” designation do not impact listed species or their designated critical habitat (hereafter listed resources) either positively or negatively, and this designation is typically only used in situations where no listed resources are present in the action area. Actions receiving a “May Affect, but Not Likely to Adversely Affect” designation have only beneficial, insignificant, or discountable effects to listed resources. Effects are considered insignificant if they are of low relative impact, undetectable, not measurable, or cannot be evaluated. Adverse effects are considered discountable if they are extremely unlikely to occur. Actions designated as “May Affect, and is Likely to Adversely Affect” will negatively impact any exposed listed resources.

ESA-listed fish species cannot hear the frequencies emitted by active underwater acoustic sources. Additionally, due to the mobile and temporary nature of the projects, the small area of the sea floor affected during the projects relative to the entire EEZ, and the possibility for fish to temporarily move away from sound that is affecting them, the response to sound exposure from active underwater acoustic sources included in the alternatives would be short term, limited to only a few individuals, and therefore, discountable (i.e., extremely unlikely to occur).

The proposed volume of sound from the use of vessels associated with project activities would be very small in comparison to sound from all the other non-project related vessel traffic in the EEZ. Impacts would be limited to temporary behavioral and stress-startle responses to individual fish or schools of fish. Because sound disturbance would be temporary or of short duration, limited to only a few individuals,

and would occur infrequently in any given project area, the response by ESA-listed fish to sound from vessels used by NOS would be discountable (i.e., extremely unlikely to occur). Although water disturbance by surface vessel and ROV wakes and underwater turbulence could temporarily disturb and displace a few individual nearby fish, effects would be temporary and minimal and limited to the project area or its immediate surroundings; thus, the response by ESA-listed fish would be discountable.

The likelihood for an accidental spill is expected to be discountable (i.e., extremely unlikely to occur), and exposure of ESA-listed fish species and critical habitats to oil, fuel, and other contaminants is not expected. These accidents may be caused by equipment malfunction, human error, or natural phenomena and are not expected during the course of NOS operations. In the extreme unlikely event of an accidental spill, there would be very low likelihood for contaminants to make contact with the water because vessel operations personnel are required to respond immediately using established spill response procedures. Thus, effects from chemical contamination on ESA-listed species are discountable (i.e., extremely unlikely to occur).

Given the minimal amount of potential turbidity and fine sediment created by disturbance of the sea floor, the effect on ESA-listed species would be discountable.

Thus, NOS concludes that the proposed project “May Affect, but Not Likely to Adversely Affect” any of the ESA-listed fish species occurring in the action area (Table 3.7-3). Additionally, these fish species serve as prey to marine mammals, and thus, effects on these fish would constitute indirect effects to marine mammals. Thus, the “May Affect, but Not Likely to Adversely Affect” determination for ESA-listed fish also applies indirectly to ESA-listed marine mammals.

Since projects may occur in some areas within or adjacent to designated critical habitats, there is the potential for impacts on critical habitat characteristics that support ESA-listed fish species. Critical habitat may be minimally disturbed but would remain functional to maintain viability of the species reliant on it. Due to the potential for effects that could be negligible or minor as discussed in the impact analysis above, the Proposed Action “May Affect, but Not Likely to Adversely Affect” the designated critical habitat occurring in the action area (Table 3.7-3).

Table 3.7-3. Summary of Effects Determinations for ESA-Listed Fish and Critical Habitat

ESA-Listed Fish	Species Determination	Critical Habitat Determination
Perch-like (Perciformes)		
Nassau grouper	May Affect, Not Likely to Adversely Affect	N/A* (no critical habitat designated)
Tidewater goby	May Affect, Not Likely to Adversely Affect	May Affect, Not Likely to Adversely Affect
Salmon, Smelts, etc. (Salmoniformes)		
Atlantic salmon (Gulf of Maine DPS)	May Affect, Not Likely to Adversely Affect	May Affect, Not Likely to Adversely Affect
Chinook salmon (California Coastal ESU)	May Affect, Not Likely to Adversely Affect	May Affect, Not Likely to Adversely Affect

ESA-Listed Fish	Species Determination	Critical Habitat Determination
Chinook salmon (Central Valley Spring-run ESU)	May Affect, Not Likely to Adversely Affect	May Affect, Not Likely to Adversely Affect
Chinook salmon (Lower Columbia River ESU)	May Affect, Not Likely to Adversely Affect	May Affect, Not Likely to Adversely Affect
Chinook salmon (Puget Sound ESU)	May Affect, Not Likely to Adversely Affect	May Affect, Not Likely to Adversely Affect
Chinook salmon (Sacramento River Winter-run ESU)	May Affect, Not Likely to Adversely Affect	May Affect, Not Likely to Adversely Affect
Chinook salmon (Snake River Fall-run ESU)	May Affect, Not Likely to Adversely Affect	May Affect, Not Likely to Adversely Affect
Chinook salmon (Snake River Spring/Summer-run ESU)	May Affect, Not Likely to Adversely Affect	May Affect, Not Likely to Adversely Affect
Chinook salmon (Upper Columbia River Spring-run ESU)	May Affect, Not Likely to Adversely Affect	May Affect, Not Likely to Adversely Affect
Chinook salmon (Upper Willamette River ESU)	May Affect, Not Likely to Adversely Affect	May Affect, Not Likely to Adversely Affect
Chinook salmon (Upper Klamath-Trinity River)	May Affect, Not Likely to Adversely Affect	NA (no critical habitat designated)
Chum salmon (Columbia River ESU)	May Affect, Not Likely to Adversely Affect	May Affect, Not Likely to Adversely Affect
Chum salmon (Hood Canal Summer-run ESU)	May Affect, Not Likely to Adversely Affect	May Affect, Not Likely to Adversely Affect
Coho salmon (Central California Coast ESU)	May Affect, Not Likely to Adversely Affect	May Affect, Not Likely to Adversely Affect
Coho salmon (Lower Columbia River ESU)	May Affect, Not Likely to Adversely Affect	May Affect, Not Likely to Adversely Affect
Coho salmon (Oregon Coast ESU)	May Affect, Not Likely to Adversely Affect	May Affect, Not Likely to Adversely Affect
Coho salmon (Southern Oregon/Northern California Coast ESU)	May Affect, Not Likely to Adversely Affect	May Affect, Not Likely to Adversely Affect
Sockeye salmon (Ozette Lake ESU)	May Affect, Not Likely to Adversely Affect	May Affect, Not Likely to Adversely Affect
Sockeye salmon (Snake River ESU)	May Affect, Not Likely to Adversely Affect	May Affect, Not Likely to Adversely Affect
Steelhead (California Central Valley DPS)	May Affect, Not Likely to Adversely Affect	May Affect, Not Likely to Adversely Affect
Steelhead (Central California Coast DPS)	May Affect, Not Likely to Adversely Affect	May Affect, Not Likely to Adversely Affect

ESA-Listed Fish	Species Determination	Critical Habitat Determination
Steelhead (Lower Columbia River DPS)	May Affect, Not Likely to Adversely Affect	May Affect, Not Likely to Adversely Affect
Steelhead (Middle Columbia River DPS)	May Affect, Not Likely to Adversely Affect	May Affect, Not Likely to Adversely Affect
Steelhead (Northern California DPS)	May Affect, Not Likely to Adversely Affect	May Affect, Not Likely to Adversely Affect
Steelhead (Puget Sound DPS)	May Affect, Not Likely to Adversely Affect	May Affect, Not Likely to Adversely Affect
Steelhead (Snake River Basin DPS)	May Affect, Not Likely to Adversely Affect	May Affect, Not Likely to Adversely Affect
Steelhead (South Central California Coast DPS)	May Affect, Not Likely to Adversely Affect	May Affect, Not Likely to Adversely Affect
Steelhead (Southern California DPS)	May Affect, Not Likely to Adversely Affect	May Affect, Not Likely to Adversely Affect
Steelhead (Upper Columbia River DPS)	May Affect, Not Likely to Adversely Affect	May Affect, Not Likely to Adversely Affect
Steelhead (Upper Willamette River DPS)	May Affect, Not Likely to Adversely Affect	May Affect, Not Likely to Adversely Affect
Bull trout (Coastal Recovery Unit)	May Affect, Not Likely to Adversely Affect	May Affect, Not Likely to Adversely Affect
Eulachon (Southern DPS)	May Affect, Not Likely to Adversely Affect	May Affect, Not Likely to Adversely Affect
Scorpionfishes (Scorpaeniformes)		
Bocaccio (Puget Sound/Georgia Basin DPS)	May Affect, Not Likely to Adversely Affect	N/A (no critical habitat designated)
Yelloweye rockfish (Puget Sound/Georgia Basin DPS)	May Affect, Not Likely to Adversely Affect	May Affect, Not Likely to Adversely Affect
Sharks, Skates, Rays, & Chimeras (Chondrichthyes)		
Giant manta ray	May Affect, Not Likely to Adversely Affect	N/A (no critical habitat designated)
Scalloped hammerhead shark (Eastern Pacific DPS)	May Affect, Not Likely to Adversely Affect	N/A (no critical habitat designated)
Scalloped hammerhead shark (Central and Southwest Atlantic DPS)	May Affect, Not Likely to Adversely Affect	N/A (no critical habitat designated)
Scalloped hammerhead shark (Indo-West Pacific DPS)	May Affect, Not Likely to Adversely Affect	N/A (no critical habitat designated)
Largetooth sawfish	May Affect, Not Likely to Adversely Affect	N/A (no critical habitat designated)

ESA-Listed Fish	Species Determination	Critical Habitat Determination
Smalltooth sawfish	May Affect, Not Likely to Adversely Affect	N/A (no critical habitat designated)
Sturgeons (Acipenseriformes)		
Atlantic sturgeon (New York Bight DPS)	May Affect, Not Likely to Adversely Affect	May Affect, Not Likely to Adversely Affect
Atlantic sturgeon (Carolina DPS)	May Affect, Not Likely to Adversely Affect	May Affect, Not Likely to Adversely Affect
Atlantic sturgeon (Chesapeake Bay DPS)	May Affect, Not Likely to Adversely Affect	May Affect, Not Likely to Adversely Affect
Atlantic sturgeon (South Atlantic DPS)	May Affect, Not Likely to Adversely Affect	May Affect, Not Likely to Adversely Affect
Atlantic sturgeon (Gulf of Maine DPS)	May Affect, Not Likely to Adversely Affect	May Affect, Not Likely to Adversely Affect
Atlantic sturgeon (Gulf of Mexico subspecies)	May Affect, Not Likely to Adversely Affect	May Affect, Not Likely to Adversely Affect
Green sturgeon (Southern DPS)	May Affect, Not Likely to Adversely Affect	May Affect, Not Likely to Adversely Affect
Shortnose sturgeon	May Affect, Not Likely to Adversely Affect	N/A (no critical habitat designated)

*N/A = Not Applicable