

5 Potentially Covered Species Habitat Use

This white paper identifies what is known about how activities associated with the construction, operation and repair of HPA-permitted activities can pose risks of take for the 52 HCP species. To understand species-specific impacts, it is important to understand the geographic distribution and habitat use of each species. Table 5-1 lists the scientific name, Water Resource Inventory Area (WRIA) of occurrence, Tidal Reference Area of occurrence, and the reproductive patterns and habitat requirements of each of these HCP species. Through the identification of species-specific habitat needs, the risk of take associated with each mechanism of impact related to HPA-permitted activities can be identified. Once the potential for take has been identified, it can be avoided. If unavoidable, the risk of take can be minimized by design and/or through conservation and protection measures.

Table 5-1. Range of occurrence of the HCP species and their habitat requirements.

Common Name	Scientific Name	Water Resource Inventory Area ^a	Tidal Reference Area ^b	Habitat Requirements and Reproduction Timing
Chinook salmon	<i>Oncorhynchus tshawytscha</i>	01–42, 44–50	All	<p>General Information (Habitats and Feeding/Life-history Types)</p> <p>NOAA Fisheries recognizes eight evolutionarily significant units (ESUs) of Chinook salmon in Washington:</p> <ol style="list-style-type: none"> (1) Upper Columbia River spring-run; (2) Snake River spring/summer run; (3) Snake River fall-run; (4) Puget Sound; (5) lower Columbia River; (6) Washington coast; (7) Mid-Columbia River spring-run; and (8) Upper Columbia River summer/fall-run. <p>Chinook salmon exhibit one of two life-history types, or races: the stream-type and the ocean-type. Stream-type Chinook tend to spend 1 (or less frequently 2) years in freshwater environments as juveniles prior to migrating to salt water as smolts. Stream-type Chinook are much more dependent on freshwater stream ecosystems than ocean-type Chinook. Stream-type Chinook do not extensively rear in estuarine and marine nearshore environments; rather, they head offshore and begin their seaward migrations. Ocean-type Chinook enter salt water at one of three phases: immediate fry migration soon after yolk is absorbed, fry migration 60–150 days after emergence, and fingerling migrants that migrate in the late summer or fall of their first year. Ocean-type Chinook are highly dependent on estuarine habitats to complete their life history. Chinook generally feed on invertebrates but become more piscivorous with age.</p> <p>Reproduction/Life History</p> <p>Chinook runs are designated on the basis of adult migration timing:</p> <ul style="list-style-type: none"> • Spring-run Chinook: Tend to enter fresh water as immature fish,

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				<p>migrate far upriver, and finally spawn in the late summer and early autumn.</p> <ul style="list-style-type: none"> • Fall-run Chinook: Enter fresh water at an advanced stage of maturity, move rapidly to their spawning areas on the mainstem or lower tributaries of the rivers, and spawn within a few days or weeks of freshwater entry. • Spring Chinook: Spawning occurs from mid-July to mid-December, and incubation lasts approximately 1.5–7 months, depending on temperature. Emergence follows, 6–8 months from fertilization. • Fall Chinook: Spawning occurs from late October to early December, with incubation occurring for 1–6 months. Emergence follows, approximately 6 months after fertilization. <p>(Healey 1991; Myers et al. 1998; WDNR 2006a; Wydoski and Whitney 2003)</p>
Coho salmon	<i>Oncorhynchus kisutch</i>	01–42, 44–48, 50	All	<p>General Information (Habitats and Feeding)</p> <p>NOAA Fisheries recognizes four ESUs of coho salmon in Washington:</p> <ol style="list-style-type: none"> (1) Lower Columbia River; (2) Southwest Washington; (3) Puget Sound and Strait of Georgia; and (4) Olympic Peninsula. <p>This species is found in a broader diversity of habitats than any of the other native anadromous salmonids. Fry feed primarily on aquatic insects and prefer pools and undercut banks with woody debris; adults feed on herring and other forage fish.</p> <p>Reproduction/Life History</p> <p>Coho adults spawn from September to late January, generally in the upper watersheds in gravel free of heavy sedimentation. Developing young remain in gravel for up to 3 months after hatching. Fry emerge from early March to late</p>

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				<p>July. Coho rear in fresh water for 12–18 months before moving downstream to the ocean in the spring. Coho spend between 1 and 2 years in the ocean before returning to spawn.</p> <p>(Groot and Margolis 1991; Murphy and Meehan 1991; WDNR 2005, 2006a; Wydoski and Whitney 2003)</p>
Chum salmon	<i>Oncorhynchus keta</i>	01, 03–05, 07–29	All	<p>General Information (Habitats and Feeding)</p> <p>NOAA Fisheries recognizes four ESUs of chum salmon in Washington:</p> <ul style="list-style-type: none"> (1) Hood Canal summer run; (2) Columbia River; (3) Puget Sound/Strait of Georgia; and (4) Pacific Coast. <p>Little is known about their ocean distribution; maturing individuals that return to Washington streams have primarily been found in the Gulf of Alaska. Chum migrate into rivers and streams of Washington coast, Hood Canal, Strait of Juan de Fuca, Puget Sound, and the Columbia River basin to spawn, but their range does not extend upstream above the Dalles Dam in the Columbia River. Fry feed on chironomid and mayfly larvae, as well as other aquatic insects, whereas juvenile fish in the estuary feed on copepods, tunicates, and euphausiids.</p> <p>Reproduction/Life History</p> <p>Chum salmon have three distinct run times: summer, fall and winter. Summer chum begin their upstream migration and spawn from mid-August through mid-October, with fry emergence ranging from the beginning of February through mid-April. Chum fry arrive in estuaries earlier than most salmon, and juvenile chum reside in estuaries longer than most other anadromous species. Chum salmon rear in the ocean for the majority of their adult lives. Fall chum adults enter the rivers from late October through November and spawn in November and December. Winter chum adults migrate upstream from December through January and spawn from January through February. Fall and winter chum fry emerge in March and April and quickly emigrate to the estuary. Chum salmon</p>

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				<p>utilize the low-gradient (from 1–2 percent grade), sometimes tidally influenced lower reaches of streams for spawning.</p> <p>(Healey 1982; Johnson et al. 1997; Quinn 2005; Salo 1991; WDNR 2005, 2006a; Wydoski and Whitney 2003)</p>
Pink salmon	<i>Oncorhynchus gorbuscha</i>	01, 03–05, 07, 09–11, 16–19, 21	1–13	<p>General Information (Habitats and Feeding)</p> <p>NOAA Fisheries recognizes two ESUs of pink salmon in Washington, neither of which is listed:</p> <p>(1) Odd-year; and</p> <p>(2) Even-year.</p> <p>Pink salmon are the most abundant species of salmon, with 13 stocks identified in Washington. They are the smallest of the Pacific salmon and mature and spawn on a 2-year cycle in Washington (primarily spawning during odd years). Adults are opportunistic feeders in marine habitat, foraging on a variety of forage fish, crustaceans, ichthyoplankton, and zooplankton. Juveniles primarily feed on small crustaceans such as euphausiids, amphipods, and cladocerans.</p> <p>Reproduction/Life History</p> <p>Pink salmon will spawn in rivers with substantial amounts of silt. Spawning occurs from August through October. Fry emerge from their redds in late February to early May, depending on water temperature, and migrate downstream to the estuary within 1 month. Juveniles remain in estuarine or nearshore waters for several months before moving offshore as they migrate to the Pacific Ocean, where they remain approximately 1 year until the next spawning cycle.</p> <p>(Hard et al. 1996; Heard 1991; WDNR 2005, 2006a)</p>
Sockeye salmon	<i>Oncorhynchus nerka</i>	01, 03–05, 07–11, 16, 19–22, 25–33, 35–37, 40, 41, 44–50	5, 8, 14	<p>General Information (Habitats and Feeding/Life-history Types)</p> <p>NOAA Fisheries recognizes seven ESUs of sockeye salmon in Washington:</p>

Common Name	Scientific Name	Water Resource Inventory Area ^a	Tidal Reference Area ^b	Habitat Requirements and Reproduction Timing
				<p>(1) Snake river; (2) Ozette Lake; (3) Baker River; (4) Okanogan River; (5) Quinault Lake; (6) Lake Pleasant; and (7) Lake Wenatchee.</p> <p>WDFW recognizes an additional sockeye salmon stock in the Big Bear Creek drainage of Lake Washington. Kokanee (landlocked sockeye) occur in many lakes, with the larger populations in Banks and Loon lakes in eastern Washington and Lake Whatcom and Lake Washington-Sammamish in western Washington. Juveniles feed on zooplankton, and adults primarily feed on fish, euphausiids, and copepods.</p> <p>Reproduction/Life History</p> <p>Spawn in shallow, gravelly habitat in rivers and lakes during August to October. Juvenile sockeye rear in lakes for 1–2 years before migrating to the ocean. Emergence occurs within 3–5 months.</p> <p>(Gustafson et al. 1997; Wydoski and Whitney 2003)</p>
Steelhead	<i>Oncorhynchus mykiss</i>	01, 03–05, 07–12, 14, 15, 17–41, 44–50	All	<p>General Information (Habitats and Feeding)</p> <p>NOAA Fisheries recognizes 15 Distinct Population Segments (DPSs) of steelhead, seven of which occur in Washington. During their ocean phase, steelhead are generally found within 10 and 25 miles of the shore; steelhead remain in the marine environment 2–4 years before returning to fresh water to spawn. Most steelhead spawn at least twice in their lifetimes. Escape cover, such as logs, undercut banks, and deep pools, is important for adult and young steelhead in the freshwater systems. The coastal west-side streams typically support more winter steelhead populations.</p>

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				<p>Reproduction</p> <p>A summer spawning run enters fresh water in August and September, and a winter run occurs from December through February. Summer steelhead usually spawn farther upstream than winter populations and dominate inland areas such as the Columbia Basin. Spawning occurs from March to April for both winter and summer run steelhead. After hatching and emergence (approximately 3 months), juveniles establish territories, feeding on microscopic aquatic organisms and then larger organisms such as isopods, amphipods, and aquatic and terrestrial insects. Steelhead rear in fresh water for up to 4 years before migrating to sea.</p> <p>(Busby et al. 1996; McKinnell et al. 1997; WDNR 2006a; Wydoski and Whitney 2003)</p>
Coastal cutthroat trout	<i>Oncorhynchus clarki clarki</i>	01–05, 07–30	All	<p>General Information (Habitats and Feeding/Life-history Types)</p> <p>NOAA Fisheries has recognized three ESUs in Washington:</p> <ol style="list-style-type: none"> (1) Puget Sound; (2) Olympic Peninsula; and (3) Southwestern Washington/Columbia River. <p>USFWS has assumed sole jurisdiction for this species. No coastal cutthroat trout DPSs are listed under the ESA in Washington. Coastal cutthroat trout exhibit varied life-history forms including:</p> <ul style="list-style-type: none"> • Resident (stays in streams after rearing in their natal streams) – Resident coastal cutthroat trout utilize small headwater streams for all of their life stages. • Fluvial (migrates to larger rivers after rearing in their natal streams). • Adfluvial (migrates to lakes after rearing in their natal streams). • Anadromous (utilizes estuaries and nearshore habitat but has been

Common Name	Scientific Name	Water Resource Inventory Area ^a	Tidal Reference Area ^b	Habitat Requirements and Reproduction Timing
				<p>caught offshore).</p> <p>Juveniles of all life forms feed primarily on aquatic invertebrates but are opportunistic feeders; adults tend to feed on smaller fish, amphibians, and crustaceans while foraging within the nearshore environment.</p> <p>Reproduction/Life History</p> <p>Coastal cutthroat trout are repeat spawners, and juveniles typically rear in the natal streams for up to 2 years. Spawning occurs from late December to February, with incubation lasting approximately 2–4 months. Emergence occurs after 4 months.</p> <p>(Johnson et al. 1999; Pauley et al. 1988; WDNR 2006a)</p>
Redband trout	<i>Oncorhynchus mykiss gardnerii</i>	37–40, 45–49, 54–57	NA	<p>General Information (Habitats and Feeding)</p> <p>Redband trout is a subspecies of rainbow trout found east of the Cascade Mountains, which prefer cool water that is less than 70°F (21°C), and occupy streams and lakes with high amounts of dissolved oxygen. Their food primarily consists of Daphnia and chironomids as well as fish eggs, fish, and insect larvae and pupae.</p> <p>Reproduction/Life History</p> <p>Spawn in streams with clean, small gravel from March through May. Incubation takes approximately 1–3 months, with emergence occurring between June and July.</p> <p>(USFS 2007)</p>
Westslope cutthroat trout	<i>Oncorhynchus clarki lewisii</i>	37–39, 44–55, 58–62	NA	<p>General Information (Habitats and Feeding/Life-history Types)</p> <p>Cutthroat trout tend to thrive in streams with extensive pool habitat and cover. The westslope is a subspecies of cutthroat trout with three possible life forms:</p> <ul style="list-style-type: none"> • Adfluvial (migrates to lakes)

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				<ul style="list-style-type: none"> • Fluvial (migrates to larger rivers) • Resident (stays in streams). <p>The headwater tributaries used by resident cutthroat are typically cold, nutrient-poor waters that result in slow growth. Fluvial and adfluvial forms can exhibit more growth due to warmer water temperatures and nutrient availability. Fry feed on zooplankton, and fingerlings feed on aquatic insect larvae. Adults feed on terrestrial and aquatic insects.</p> <p>Reproduction/Life History</p> <p>Spawning: all three life forms spawn in small gravel substrates of tributary streams in the spring (March to July) when water temperature is about 50°F (10°C); incubation occurs during April to August, and emergence occurs from May through August. Fry spend 1–4 years in their natal stream before migrating to their ultimate habitat.</p> <p>(Liknes and Graham 1988; Shepard et al. 1984; Wydoski and Whitney 2003)</p>
Bull trout	<i>Salvelinus confluentus</i>	01, 03–05, 07–23, 26, 27, 29–41, 44–55, 57–62	All	<p>General Information (Habitats and Feeding/Life-History Types)</p> <p>Widely distributed in Washington; exhibit four life-history types:</p> <ul style="list-style-type: none"> • Resident (stays in streams after rearing in their natal streams) • Fluvial (migrates to larger rivers after rearing in their natal streams) • Adfluvial (migrates to lakes after rearing in their natal streams) • Anadromous (bull trout in the nearshore ecosystem rely on estuarine wetlands and favor irregular shorelines with unconsolidated substrates). <p>Young of the year occupy side channels, with juveniles in pools, runs, and riffles; adults occupy deep pools. Juvenile diet includes larval and adult aquatic insects; subadults and adults primarily feed on fish.</p> <p>Reproduction/Life History</p> <p>The migratory forms of bull trout, such as anadromous, adfluvial, and fluvial,</p>

Common Name	Scientific Name	Water Resource Inventory Area ^a	Tidal Reference Area ^b	Habitat Requirements and Reproduction Timing
				<p>move upstream by early fall to spawn in September and October (November at higher elevations). Although resident bull trout are already in stream habitats, they move upstream looking for suitable spawning habitat. They prefer clean, cold water (50°F [10°C]) for spawning. Colder water (36–39°F [2–4°C]) is required for incubation. Preferred spawning areas often include groundwater infiltration. Extended incubation periods (up to 220 days) make eggs and fry particularly susceptible to increases in fine sediments. Bull trout typically rear in natal streams for 2–4 years, although resident fish may remain in these streams for their entire lives; multiple life-history forms may occur in the same habitat environments.</p> <p>(Goetz et al. 2004; WDNR 2005, 2006a; Wydoski and Whitney 2003)</p>
Dolly Varden	<i>Salvelinus malma</i>	01, 03, 05, 07, 17–22, 24	6–10, 14–17	<p>General Information (Habitats and Feeding/Life-History Types)</p> <p>Species restricted to coastal areas and rivers that empty into them. Juveniles extensively use instream cover; while in the marine systems, they use beaches of sand and gravel. Prefer pool areas and cool temperatures. Feed opportunistically on aquatic insects, crustaceans, salmon eggs, and fish. Closely related to bull trout and exhibit the same life-history traits. Four life-history types occur:</p> <ul style="list-style-type: none"> • Resident (stays in streams after rearing in their natal streams) • Fluvial (migrates to larger rivers after rearing in their natal streams) • Adfluvial (migrates to lakes after rearing in their natal streams) • Anadromous (migrates to marine waters after rearing in their natal streams). <p>Reproduction/Life History</p> <p>Spawn and rear in streams from mid-September through November. Incubation lasts approximately 130 days. Juveniles can spend 2–4 years in their natal streams before migration to marine waters.</p> <p>(Leary and Allendorf 1997; WDNR 2005; Wydoski and Whitney 2003)</p>

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Pygmy whitefish	<i>Prosopium coulteri</i>	08, 19, 39, 47, 49, 53, 55, 58, 59, 62	NA	<p>General Information (Habitats and Feeding)</p> <p>In Washington, pygmy whitefish occur at the extreme southern edge of their natural range; pygmy whitefish were once found in at least 15 Washington lakes but have a current distribution in only nine. They occur most often in deep, oligotrophic lakes with temperatures less than 50°F (10°C), where they feed on zooplankton, such as cladocerans, copepods, and midge larvae.</p> <p>Reproduction/Life History</p> <p>Pygmy whitefish spawn in streams or lakes from July through November. They prefer pools, shallow riffles, and pool tail-outs when spawning in streams. Lake spawning by pygmy whitefish occurs at night. Spawning occurs by scattering their eggs over coarse gravel. Incubation and emergence timing are unknown, but eggs are believed to hatch in the spring.</p> <p>(Hallock and Mongillo 1998; WDNR 2005, 2006a; Wydoski and Whitney 2003)</p>
Olympic mudminnow	<i>Novumbra hubbsi</i>	08–24	NA	<p>General Information (Habitats and Feeding)</p> <p>Occur in the southern and western lowlands of the Olympic Peninsula, the Chehalis River drainage, lower Deschutes River drainage, south Puget Sound lowlands west of the Nisqually River, and in King County. They are generally found in quiet water with mud substrate, preferring bogs and swamps with dense aquatic vegetation. Mudminnows feed on annelids, insects, and crustaceans.</p> <p>Reproduction/Life History</p> <p>Adults spawn from November through June (peaking in April and May). Females deposit eggs onto vegetation where fry remain firmly attached for approximately 1 week after hatching. Incubation lasts approximately 8-10 days.</p> <p>(Harris 1974; Mongillo and Hallock 1999; WDNR 2005, 2006a)</p>
Lake chub	<i>Couesius plumbeus</i>	48, 61; other locations unknown	NA	<p>General Information (Habitats and Feeding)</p> <p>Bottom dwellers inhabiting a variety of habitats in lakes and streams, but are known to prefer small, slow streams. In Washington, they are known only from</p>

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				<p>the northeastern part of the state (small streams and lakes in Okanogan and Stevens counties). Juveniles feed on zooplankton and phytoplankton, whereas adults primarily feed on insects.</p> <p>Reproduction/Life History</p> <p>Lake chub move into shallow areas on rocky and gravelly substrates in tributary streams of lakes or lakeshores during the spring to spawn when water temperatures are between 55 and 65°F (13 and 18°C). The eggs are broadcast over large rocks and then settle into the smaller substrate, hatching after approximately 10 days.</p> <p>(WDNR 2005; Wydoski and Whitney 2003)</p>
Leopard dace	<i>Rhinichthys falcatus</i>	25–31, 37–41, 44–50	NA	<p>General Information (Habitats and Feeding)</p> <p>In Washington, leopard dace inhabit the bottoms of streams and small to mid-sized rivers, specifically the Columbia, Snake, Yakima, and Simikameen Rivers, with velocities less than 1.6 ft/sec (0.5 m/sec); prefer gravel and small cobble substrate covered by fine sediment with summer water temperatures ranging between 59 and 64°F (15 and 18°C). Juveniles feed primarily on aquatic insects; adult leopard dace consume terrestrial insects.</p> <p>Reproduction/Life History</p> <p>Breeding habitat for dace generally consists of the gravel or cobble bottoms of shallow riffles; leopard dace breed in slower, deeper waters than the other dace species. The spawning period for dace is from May through July. The eggs adhere to rocky substrates. Fry hatch approximately 6–10 days after fertilization, and juveniles spend 1–3 months rearing in shallow, slow water.</p> <p>(WDNR 2005, 2006a; Wydoski and Whitney 2003)</p>
Margined sculpin	<i>Cottus marginatus</i>	32, 35	NA	<p>General Information (Habitats and Feeding)</p> <p>Endemic to southeastern Washington (smaller tributary streams of the Walla Walla and Tucannon River drainages) where habitat is in deeper pools and slow-moving glides in headwater tributaries with silt and small gravel substrate. They</p>

Common Name	Scientific Name	Water Resource Inventory Area ^a	Tidal Reference Area ^b	Habitat Requirements and Reproduction Timing
				<p>prefer cool water less than 68°F (20°C) and avoid high-velocity areas. Food includes immature aquatic insects, invertebrates, small fish, and eggs.</p> <p>Reproduction/Life History</p> <p>Spawning occurs in May and June primarily under rocks, root wads, or logs. The female deposits a mass of adhesive eggs in the nest, which is guarded by the male. Incubation duration unknown.</p> <p>(Mongillo and Hallock 1998; WDNR 2005; Wydoski and Whitney 2003)</p>
Mountain sucker	<i>Catostomus platyrhynchus</i>	25–35, 37–41, 44–50	NA	<p>General Information (Habitats and Feeding)</p> <p>Distribution restricted to Columbia River system. Found in clear, cold mountain streams less than 40 ft wide and in some lakes; prefer deep pools in summer with moderate current. Food consists of algae and diatoms. Juveniles prefer slower side channels or weedy backwaters.</p> <p>Reproduction/Life History</p> <p>Males reach sexual maturity in 2–3 years and females in 4 years. Spawning in June and July when water temperatures exceed 50°F (10°C). Spawning occurs in gravelly riffles of small streams when suckers move into those reaches to feed on algae. Spawning likely occurs at night when water temperatures are in a range of 51–66°F (10.5–19°C). Fertilized eggs fall into and adhere to the spaces between the gravel composite. Incubation period lasts approximately 8-14 days.</p> <p>(Wydoski and Whitney 2003)</p>
Umatilla dace	<i>Rhinichthys umatilla</i>	31, 36–41, 44–50, 59–61	NA	<p>General Information (Habitats and Feeding)</p> <p>Umatilla dace are benthic fish found in relatively productive, low-elevation streams with clean substrates of rock, boulders, and cobbles in reaches where water velocity is less than 1.5 ft/sec (0.5 m/sec). Feeding is similar to that described for leopard dace. Juveniles occupy streams with cobble and rubble substrates, whereas adults occupy deeper water habitats.</p>

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				<p>Reproduction/Life History</p> <p>Spawning behaviors are similar to those described for leopard dace, with spawning primarily occurring from early to mid-July.</p> <p>(WDNR 2005, 2006a; Wydoski and Whitney 2003)</p>
Pacific lamprey	<i>Lampetra tridentata</i>	01, 03–05, 07–35, 37–40, 44–50	All	<p>General Information (Habitats and Feeding)</p> <p>Found in most large coastal and Puget Sound rivers and Columbia, Snake, and Yakima river basins. The larvae are filter feeders, residing in mud substrates and feeding on algae and other organic matter for at least 5 years.</p> <p>Reproduction/Life History</p> <p>From July through October, maturing Pacific lamprey enter fresh water and gradually move upstream to spawn the following spring. The nest usually consists of a shallow depression built in gravel and rock substrates. Eggs hatch in 2–4 weeks, with newly hatched larvae remaining in the nest for 2–3 weeks before moving downstream as larvae (ammocoetes). Juveniles migrate to the Pacific Ocean 4–7 years after hatching and attach to fish in the ocean for 20–40 months before returning to rivers to spawn.</p> <p>(WDNR 2005; Wydoski and Whitney 2003)</p>
River lamprey	<i>Lampetra ayresi</i>	01, 03, 05, 07–16, 20–40	1–9, 11–17	<p>General Information (Habitats and Feeding)</p> <p>Detailed distribution records are not available for Washington, but they are known to inhabit coastal rivers, estuaries, and the Columbia River system. They have also been observed in Lake Washington and its tributaries. In the marine system, river lamprey inhabit nearshore areas. Adults are anadromous living in the marine system as parasites on fish. Adult river lamprey are believed to occupy deep portions of large river systems. The larvae feed on microscopic plants and animals.</p> <p>Reproduction/Life History</p> <p>Adults migrate back into fresh water in the fall. Spawning occurs in winter and</p>

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				<p>spring. Eggs hatch in 2–3 weeks after spawning. Juveniles are believed to migrate from their natal rivers to the Pacific Ocean several years after hatching; adults spend 10–16 weeks between May and September in the ocean before migrating to fresh water.</p> <p>(WDNR 2005; Wydoski and Whitney 2003)</p>
Western brook lamprey	<i>Lampetra richardsoni</i>	01, 03, 05, 07–14, 16, 20–40	NA	<p>General Information (Habitats and Feeding)</p> <p>Found in small coastal and Puget Sound rivers and lower Columbia and Yakima river basins; spends entire life in fresh water. Adults are found in cool water (52–64°F [11–17.8°C]) on pebble/rocky substrate. Larvae (ammocoetes) are filter feeders, consuming primarily diatoms. Adults do not feed and die within a month of spawning.</p> <p>Reproduction/Life History</p> <p>Spawning generally occurs from April through July, with adults creating nests in coarse gravel at the head of riffles. Eggs hatch after about 10 days in water between 50 and 60°F (10 and 16°C). Within 30 days of hatching, ammocoetes emerge from the nests and move to the stream margin, where they burrow into silty substrates. Larvae remain in the stream bottom—apparently moving little—for approximately 4–6 years.</p> <p>(Wydoski and Whitney 2003)</p>
Green sturgeon	<i>Acipenser medirostris</i>	22, 24, 28	All	<p>General Information (Habitats and Feeding)</p> <p>NOAA Fisheries recognizes two DPSs of green sturgeon, both of which can be found in Washington. The southern DPS is listed as threatened and the northern DPS is a species of concern. Habits and life history not well known. Washington waters with green sturgeon populations include the Columbia River, Willapa Bay, and Grays Harbor, in addition to marine waters. They spend much of their life in marine nearshore waters and estuaries feeding on fishes and invertebrates.</p> <p>Reproduction/Life History</p> <p>Spawning generally occurs in spring in deep, fast-flowing sections of rivers.</p>

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				<p>Spawning habitat includes cobble or boulder substrates. Green sturgeon move upstream during spring to spawn and downstream during fall and winter. Large eggs sink to bottom.</p> <p>(Adams et al. 2002; Emmett et al. 1991; Kynard et al. 2005; Nakamoto and Kisanuki 1995; Wydoski and Whitney 2003)</p>
White sturgeon	<i>Acipenser transmontanus</i>	01, 03, 05–22, 24–37, 40–42, 44–61	All	<p>General Information (Habitats and Feeding)</p> <p>Found in marine waters and major rivers in Washington, including the Columbia River, Snake River, Grays Harbor, Willapa Bay, Puget Sound, and Lake Washington. In marine environments, adults and subadults use estuarine and marine nearshore habitats, including some movement into intertidal flats to feed at high tide. Some landlocked populations exist behind dams on the Columbia River. Juveniles feed on mysid shrimp and amphipods; large fish feed on variety of crustaceans, annelid worms, mollusks, and fish.</p> <p>Reproduction/Life History</p> <p>Spawn in deep, fast-flowing sections of rivers (prefer swift [2.6–9.2 ft/sec (0.8–2.8 m/sec)] and deep [13–66 ft (4–20 m)] water) on bedrock, cobble, or boulder substrates. Spawning occurs from April through July, with incubation lasting approximately 7 days and emergence following in another 7 days.</p> <p>(Emmett et al. 1991; WDNR 2005; Wydoski and Whitney 2003)</p>
Eulachon	<i>Thaleichthys pacificus</i>	01–29 (mouths of major rivers)	14–17	<p>General Information (Habitats and Feeding)</p> <p>Eulachon occur from northern California to southwestern Alaska in offshore marine waters. They are plankton-feeders, eating crustaceans such as copepods and euphausiids; larvae and post larvae eat phytoplankton and copepods. They are an important prey species for fish, marine mammals, and birds.</p> <p>Reproduction/Life History</p> <p>Spawn in tidal portions of rivers in spring when water temperature is 40–50°F (4–10°C), generally from March through May; use a variety of substrates, but sand and gravel are most common. Eggs stick to substrate and incubation ranges</p>

Common Name	Scientific Name	Water Resource Inventory Area ^a	Tidal Reference Area ^b	Habitat Requirements and Reproduction Timing
				<p>from 20–40 days (dependent on temperature). Larvae drift downstream to salt water where juveniles rear in nearshore marine areas.</p> <p>(Howell et al. 2001; Langer et al. 1977; Lewis et al. 2002; WDFW 2001; WDNR 2005; Willson et al. 2006)</p>
Longfin smelt	<i>Spirinchus thaleichthys</i>	01–03, 05–17, 22 and 24	1–9, 15–17	<p>General Information (Habitats and Feeding)</p> <p>Marine species that spawns in streams not far from marine waters. They are anadromous, with some populations in Lake Washington that spawn in tributaries, including the Cedar River. Juveniles use nearshore habitats and a variety of substrates; juveniles feed on zooplankton. Adults feed on copepods and euphausiids. Most adults die after spawning.</p> <p>Reproduction</p> <p>Spawn in coastal rivers from October through December. Lake Washington populations spawn from January through April. Eggs hatch in approximately 40 days and the larvae drift downstream to salt water.</p> <p>(Gotthardt 2006; WDNR 2005; Wydoski and Whitney 2003)</p>
Pacific sand lance	<i>Ammodytes hexapterus</i>	NA	All	<p>General Information (Habitats and Feeding)</p> <p>Widespread in Puget Sound, Strait of Juan de Fuca, and coastal estuaries. Schooling plankton feeders. Adults feed during the day and burrow into the sand at night.</p> <p>Reproduction/Life History</p> <p>Spawn on sand and beaches with gravel up to 1-inch in diameter at tidal elevations of +4–5 ft (+1.5 meters) to approximately the mean higher high water (MHHW) line from November through February. Emergence occurs from January to April. Larvae and young rear in bays and nearshore areas.</p> <p>(Garrison and Miller 1982; Nightingale and Simenstad 2001b; NRC 2001; Penttila 2000; Penttila 2001; WDFW 1997a)</p>

Common Name	Scientific Name	Water Resource Inventory Area ^a	Tidal Reference Area ^b	Habitat Requirements and Reproduction Timing
Surf smelt	<i>Hypomesus pretiosus</i>	NA	All	<p>General Information (Habitats and Feeding)</p> <p>Schooling plankton-feeding forage fish. They feed on a variety of zooplankton, planktonic crustaceans, and fish larvae. Adult surf smelt are pelagic but remain in nearshore habitats. Juveniles rear in nearshore areas, and adults form schools offshore; feed on planktonic organisms. Also an important forage fish.</p> <p>Reproduction/Life History</p> <p>Spawning occurs year-round in north Puget Sound, fall and winter in south Puget Sound, and summer along the coast. They spawn at the highest tides during high slack tide on coarse sand and pea gravel. Incubation is 2–5 weeks. Emergence varies with season: 27–56 days in winter, 11–16 days in summer.</p> <p>(Nightingale and Simenstad 2001b; NRC 2001; Penttila 2000; Penttila 2001; WDFW 1997c)</p>
Pacific herring	<i>Clupea harengus pallasi</i>	NA	1, 2, 4, 5, 8–13, 16, 17	<p>General Information (Habitats and Feeding)</p> <p>Eighteen separate stocks in Puget Sound. Widely distributed throughout Puget Sound and coastal wetlands and estuaries. Pacific herring adults feed on small fish, copepods, decapod crab larvae, and euphausiids. Juveniles feed primarily on euphausiids, copepods, and small crustacean larvae. Are also an important forage fish.</p> <p>Reproduction/Life History</p> <p>Utilize intertidal and subtidal habitats (between 0 and -40 ft [0 and -12.2 m] mean lower low water [MLLW]) for spawning and juvenile rearing; spawning also occurs above MLLW. Spawning occurs from late January to early April. Eggs are adhered to eelgrass, kelp, seaweed, and sometimes on pilings. Eggs hatch after approximately 10 days. Larvae are pelagic.</p> <p>(Nightingale and Simenstad 2001b; Penttila 2000; Simenstad et al. 1979; WDFW 1997b)</p>
Lingcod	<i>Ophiodon</i>	NA	All	<p>General Information (Habitats and Feeding)</p>

Common Name	Scientific Name	Water Resource Inventory Area ^a	Tidal Reference Area ^b	Habitat Requirements and Reproduction Timing
	<i>elongatus</i>			<p>The lingcod is a large top-level carnivore fish found throughout the West Coast of North America. Adult lingcod have a relatively small home range. Juveniles prefer sand habitats near the mouths of bays and estuaries, while adults prefer rocky substrates. Larvae and juveniles are generally found in upper 115 ft (35 m) of water. Adults prefer slopes of submerged banks with macrophytes and channels with swift currents. Larvae feed on copepods and amphipods; juveniles feed on small fishes; and adults on fish, squid, and octopi.</p> <p>Reproduction/Life History</p> <p>Spawn in shallow water and intertidal zone from January through late March. Egg masses adhere to rocks, and incubation is from February to June. Larvae spend 2 months in pelagic nearshore habitat.</p> <p>(Adams and Hardwick 1992; Emmett et al. 1991; Giorgi 1981; NMFS 1990; NRC 2001)</p>
Pacific cod	<i>Gadus macrocephalus</i>	NA	All	<p>General Information (Habitats and Feeding)</p> <p>Pacific cod are widely distributed in relatively shallow marine waters throughout the northern Pacific Ocean (Washington’s inland marine waters are considered the southern limit of populations). Adults and large juveniles are found over clay, mud, and coarse gravel bottoms; juveniles use shallow vegetated habitats such as sand-eelgrass. Feed opportunistically on invertebrates (worms, crabs, shrimp) and fishes (sand lance, pollock, flatfishes). Larvae feed on copepods, amphipods, and mysids.</p> <p>Reproduction/Life History</p> <p>Broadcast spawners during late fall through early spring. Eggs sink and adhere to the substrate. Incubate for 1–4 weeks, and larvae spend several months in the water column. Juvenile cod metamorphose and settle to shallow vegetated habitats.</p> <p>(Albers and Anderson 1985; Bargmann 1980; Dunn and Matarese 1987; Garrison and Miller 1982; Hart 1973; Nightingale and Simenstad 2001b; NMFS 1990; NRC 2001)</p>

Common Name	Scientific Name	Water Resource Inventory Area ^a	Tidal Reference Area ^b	Habitat Requirements and Reproduction Timing
Pacific hake	<i>Merluccius productus</i>	NA	All	<p>General Information (Habitats and Feeding)</p> <p>Pacific hake are schooling fish. The coastal stock of hake is migratory; Puget Sound stocks reside in estuaries and rarely migrate. Larvae feed on calanoid copepods; juveniles and small adults feed on euphausiids; adults eat amphipods, squid, herring, and smelt.</p> <p>Reproduction/Life History</p> <p>Puget Sound spawning occurs from March through May at mid-water depths of 50–350 ft (15–90 m); may spawn more than once per season. Eggs and larvae are pelagic.</p> <p>(Bailey 1982; McFarlane and Beamish 1986; NMFS 1990; NRC 2001; Quirollo 1992)</p>
Walleye pollock	<i>Theragra chalcogramma</i>	NA	All	<p>General Information (Habitats and Feeding)</p> <p>Widespread species in northern Pacific. Washington is the southern end of their habitat. Larvae and small juveniles are found at 200-ft (60-m) depth; juveniles use nearshore habitats of a variety of substrates. Juveniles feed on small crustaceans, adults feed on copepods, euphausiids, and young pollock.</p> <p>Reproduction/Life History</p> <p>Broadcast spawning occurs from February through April. Eggs are suspended at depths ranging from 330–1,320 ft (100–400 m). Pelagic larvae settle near the bottom and migrate to inshore, shallow habitats for their first year.</p> <p>(Bailey et al. 1999; Garrison and Miller 1982; Livingston 1991; Miller et al. 1976; NRC 2001)</p>
Black rockfish	<i>Sebastes melanops</i>	NA	All	<p>General Information (Habitats and Feeding)</p> <p>Adults prefer deep and shallow rock substrates in summer, deeper water in winter. Kelp and eelgrass are preferred habitat for juveniles that feed on nekton and zooplankton. Adults feed on amphipods, crabs, copepods, and small fish.</p>

Common Name	Scientific Name	Water Resource Inventory Area ^a	Tidal Reference Area ^b	Habitat Requirements and Reproduction Timing
				<p>Reproduction/Life History</p> <p>Spawning occurs from February through April; ovoviviparous incubation as with other rockfish species. Larvae are planktonic for 3–6 months, where they are dispersed by currents, advection, and upwelling. They begin to reappear as young-of-the-year fish in shallow, nearshore waters.</p> <p>(Kramer and O’Connell 1995; WDNR 2006a)</p>
Bocaccio rockfish	<i>Sebastes paucispinis</i>	NA	All	<p>General Information (Habitats and Feeding)</p> <p>Adults semidemersal in shallow water over rocks with algae, eelgrass, and floating kelp. Larvae feed on diatoms; juveniles feed on copepods and euphausiids.</p> <p>Reproduction/Life History</p> <p>Ovoviviparous spawning occurs year-round, with incubation lasting 40–50 days. Larvae and juveniles are pelagic.</p> <p>(Garrison and Miller 1982; Hart 1973; Kramer and O’Connell 1995; MBC Applied Environmental Sciences 1987; NRC 2001; Sumida and Moser 1984)</p>
Brown rockfish	<i>Sebastes auriculatus</i>	NA	All	<p>General Information (Habitats and Feeding)</p> <p>Utilize shallow-water bays with natural and artificial reefs and rock piles; estuaries used as nurseries; can tolerate water temperatures to at least 71°F (22°C); eat small fishes, crabs, and isopods.</p> <p>Reproduction/Life History</p> <p>Spawning occurs from March through June. Larvae are released from the female into the pelagic environment in May and June (ovoviviparous incubation). Larvae live in the upper zooplankton layer for up to 1 month before they metamorphose into pelagic juveniles. The pelagic juveniles spend 3–6 months in the water column as plankton. They then settle in shallow water nearshore, later migrating to deeper water.</p>

Common Name	Scientific Name	Water Resource Inventory Area ^a	Tidal Reference Area ^b	Habitat Requirements and Reproduction Timing
				(Eschmeyer et al. 1983; Kramer and O'Connell 1995; Love et al. 1990; NRC 2001; Stein and Hassler 1989)
Canary rockfish	<i>Sebastes pinniger</i>	NA	All	<p>General Information (Habitats and Feeding)</p> <p>Adults use sharp drop-offs and pinnacles with hard bottoms; often associated with kelp beds; feed on krill and occasionally on fish. Adults are mostly found at depths of 260–660 ft (80–200 meters) (with two recorded at 2,750 ft [838 meters]), tending to collect in groups around pinnacles and similar high-relief rock formations, especially where the current is strong. Young canary rockfish live in relatively shallow water, moving to deeper water as they mature. Juveniles feed on small crustacea such as krill larvae (and eggs), copepods, and amphipods, while adults eat krill and small fish.</p> <p>Reproduction/Life History</p> <p>Spawning is ovoviviparous and occurs from January through March. Larvae and juveniles are pelagic.</p> <p>(Boehlert 1980; Boehlert and Kappenman 1980; Boehlert et al. 1989; Hart 1973; Kramer and O'Connell 1995; Love et al. 1990; NRC 2001; Sampson 1996)</p>
China rockfish	<i>Sebastes nebulosis</i>	NA	All	<p>General Information (Habitats and Feeding)</p> <p>Occur inshore and on open coast in sheltered crevices. Feed on crustacea (brittle stars and crabs), octopi, and fish. Juveniles are pelagic, but the adults are sedentary associating with rocky reefs or cobble substrates.</p> <p>Reproduction/Life History</p> <p>Spawning occurs from January through July; ovoviviparous incubation as with other rockfish species. Individual China rockfish spawn once a year. Larvae settle out of the plankton between 1 and 2 months after release.</p> <p>(Eschmeyer et al. 1983; Kramer and O'Connell 1995; Love et al. 1990; NRC 2001; Rosenthal et al. 1988)</p>

Common Name	Scientific Name	Water Resource Inventory Area ^a	Tidal Reference Area ^b	Habitat Requirements and Reproduction Timing
Copper rockfish	<i>Sebastes caurinus</i>	NA	All	<p>General Information (Habitats and Feeding)</p> <p>Occur both inshore and on open coast; adults prefer rocky areas in shallower water than other rockfish species. Juveniles use shallow and nearshore macrophytes and eelgrass habitat; feed on crustaceans, fish, and mollusks.</p> <p>Reproduction/Life History</p> <p>Spawning occurs from March through May, with ovoviparous incubation from April to June. Larvae are pelagic in deeper water before moving inshore. Newly spawned fish begin settling near the surface around large algae canopies or eelgrass, when available, or closer to the bottom when lacking canopies.</p> <p>(Eschmeyer et al. 1983; Haldorson and Richards 1986; Kramer and O'Connell 1995; Matthews 1990; NRC 2001; Stein and Hassler 1989)</p>
Greenstriped rockfish	<i>Sebastes elongates</i>	NA	All	<p>General Information (Habitats and Feeding)</p> <p>Adults found in benthic and mid-water columns. They live at between 330 and 825 ft (100 and 250 m). As they age, greenstriped rockfish move to deeper water. They are solitary and are often found resting on the seafloor and living among cobble, rubble, or mud. Adults feed on euphausiids, small fish, and squid.</p> <p>Reproduction/Life History</p> <p>From 10,000 to over 200,000 eggs are produced by the females each season by ovoviparous spawning. Greenstriped rockfish release one brood of larvae in Washington. Larval release varies, occurring generally from January through July, depending on geographic location.</p> <p>(Eschmeyer et al. 1983; Kramer and O'Connell 1995; Love et al. 1990; NRC 2001)</p>
Quillback rockfish	<i>Sebastes maliger</i>	NA	All	<p>General Information (Habitats and Feeding)</p> <p>Shallow-water benthic species in inlets near shallow rock piles and reefs. Juveniles use eelgrass, sand, and kelp beds. Feed on amphipods, crabs, and</p>

Common Name	Scientific Name	Water Resource Inventory Area ^a	Tidal Reference Area ^b	Habitat Requirements and Reproduction Timing
				copepods. Reproduction/Life History Ovoviviparous spawning from April through July, with larval release from May to July. (Kramer and O'Connell 1995; WDNR 2006a)
Redstripe rockfish	<i>Sebastes proriger</i>	NA	All	General Information (Habitats and Feeding) Adults found from 330- to 1,000-ft (100- to 300-m) depths, and young often found in estuaries in high- and low-relief rocky areas. Juveniles feed on copepods and euphausiids; adults eat anchovies, herring, and squid. Reproduction/Life History Spawning is ovoviviparous, occurring from January through March. Larvae and juveniles are pelagic. (Garrison and Miller 1982; Hart 1973; Kendall and Lenarz 1986; Kramer and O'Connell 1995; NRC 2001; Starr et al. 1996)
Tiger rockfish	<i>Sebastes nigrocinctus</i>	NA	All	General Information (Habitats and Feeding) Semidemersal to demersal species occurring at depths ranging from shallows to 1,000 ft (305 m); larvae and juveniles occur near surface and range of depth; adults use rocky reefs, canyons, and headlands; generalized feeders on shrimp, crabs, and small fishes. Reproduction/Life History Ovoviviparous spawning peaks in May and June. Juveniles are pelagic. (Garrison and Miller 1982; Kramer and O'Connell 1995; Moulton 1977; NRC 2001; Rosenthal et al. 1988)
Widow	<i>Sebastes</i>	NA	All	General Information (Habitats and Feeding)

Common Name	Scientific Name	Water Resource Inventory Area ^a	Tidal Reference Area ^b	Habitat Requirements and Reproduction Timing
rockfish	<i>entomelas</i>			<p>Adults found from 330- to 1,000-ft (100- to 300-m) depths near rocky banks, ridges, and seamounts; adults feed on pelagic crustaceans, Pacific hake, and squid; juveniles feed on copepods and euphausiids.</p> <p>Reproduction /Life History</p> <p>Ovoviviparous spawning occurs from October through December. One brood of 95,000 to 1,113,000 eggs are produced by female widows per year. The season of larval release occurs earlier in the southern parts of their range than in the northern regions, likely January through April in Washington waters.</p> <p>(Eschmeyer et al. 1983; Kramer and O'Connell 1995; Laroche and Richardson 1981; NMFS 1990; NRC 2001; Reilly et al. 1992)</p>
Yelloweye rockfish	<i>Sebastes ruberrimus</i>	NA	All	<p>General Information (Habitats and Feeding)</p> <p>Adults are found from depths of 80–1,800 ft (24–550 m), near reefs and cobble bottom. Juveniles prefer shallow, broken-bottom habitat. Juveniles often hide in rock crevices; adults are demersal and solitary, tending to remain localized and not making extensive migrations. Adults feed on other rockfish species, sand lance, herring, shrimp, rock crabs, and snails.</p> <p>Reproduction/Life History</p> <p>Ovoviviparous spawning in late fall or early winter, with the larvae released from May to July.</p> <p>(Eschmeyer et al. 1983; Hart 1973; Kramer and O'Connell 1995; NRC 2001; Rosenthal et al. 1988)</p>
Yellowtail rockfish	<i>Sebastes flavidus</i>	NA	All	<p>General Information (Habitats and Feeding)</p> <p>Adults found from 165- to 1,000-ft (50- to 300-m) depths; adults semipelagic or pelagic over steep-sloping shores and rocky reefs. Juveniles occur in nearshore areas. Adults are opportunistic feeders on pelagic animals including hake, herring, smelt, squid, krill, and euphausiids.</p>

Common Name	Scientific Name	Water Resource Inventory Area ^a	Tidal Reference Area ^b	Habitat Requirements and Reproduction Timing
				<p>Reproduction/Life History</p> <p>Ovoviviparous spawning from October through December. Incubation is between January and March. Larvae and juveniles are pelagic swimmers.</p> <p>(Eschmeyer et al. 1983; Kramer and O'Connell 1995; Love et al. 1990; NRC 2001; O'Connell and Carlile 1993)</p>
Olympia oyster	<i>Ostrea lurida</i>	NA	1–14, 17	<p>General Information (Habitats and Feeding)</p> <p>Species found throughout the inland waters of Puget Sound, as well as in Willapa Bay and possibly Grays Harbor; also grown commercially in Puget Sound. They occupy nearshore ecosystem on mixed substrates with solid attachment surfaces and are found from 1 ft (0.3 m) above MLLW to 2 ft (0.6m) below MLLW. Intolerant of siltation.</p> <p>Reproduction/Life History</p> <p>Reproduce spring to fall when water temperatures are between 54 and 61°F (12.5 and 16°C) by broadcast spawning. After 8–12 days, larvae develop into free-swimming larvae. Larvae are free-swimming for 2–3 weeks before they settle onto hard substrate, such as oyster shells and rocks.</p> <p>(Baker 1995; Couch and Hassler 1990; West 1997)</p>
Northern abalone	<i>Haliotis kamtschatkana</i>	NA	10	<p>General Information (Habitats and Feeding)</p> <p>Also known as pinto abalone. Presence in Washington is limited to the Strait of Juan de Fuca and the San Juan Islands. Occupies bedrock and boulders from extreme low water to 100 ft (30 m) below MLLW; usually associated with kelp beds. The abalone is completely vegetarian and uses its radula to scrape pieces of algae from the surface of rocks.</p> <p>Reproduction/Life History</p> <p>Broadcast spawners that release pelagic gametes that develop into free-swimming larvae using cilia to propel themselves. After up to a week, the larvae settle to the bottom, shed their cilia, and start growing a shell to begin sedentary</p>

Common Name	Scientific Name	Water Resource Inventory Area ^a	Tidal Reference Area ^b	Habitat Requirements and Reproduction Timing
				adult life on crustose coralline algae. (Gardner 1981; NMFS 2007a; WDNR 2006b; West 1997)
Newcomb's littorine snail	<i>Algamorda subrotundata</i>	NA	14–17	<p>General Information (Habitats and Feeding)</p> <p>Found in Grays Harbor and Willapa Bay on Washington coast; current distribution uncertain. Algae feeder occupying narrow band in <i>Salicornia</i> salt marshes above MHHW and is not considered a true marine gastropod.</p> <p>Reproduction/Life History</p> <p>Broadcast spawning in salt marshes. Other reproductive information unknown. (Larsen et al. 1995)</p>
Giant Columbia River limpet	<i>Fisherola nuttalli</i>	35, 36, 40, 45, 47–49	NA	<p>General Information (Habitats and Feeding)</p> <p>Also known as the shortface lanx, it occupies fast-moving and well-oxygenated streams. It is found in the Hanford Reach segment of the Columbia River, Wenatchee, Deschutes (OR), Okanogan, Snake, and Methow rivers. Prefers shallow, rocky areas of cobble to boulder substrates and diatom-covered rocks, and feeds by grazing on algae attached to rocks.</p> <p>Reproduction/Life History</p> <p>Broadcast external fertilization. Reproduction timing is unknown. (Neitzel and Frest 1989; Neitzel and Frest 1990; Pacific Biodiversity Institute 2007)</p>
Great Columbia River spire snail	<i>Fluminicola columbiana</i>	35, 45, 48, 49; other locations unknown	NA	<p>General Information (Habitats and Feeding)</p> <p>Also known as the Columbia pebblesnail and ashy pebblesnail, its current range is restricted to rivers, streams, and creeks of the Columbia River basin. It requires clear, cold streams with highly oxygenated water and is generally found in shallow water (less than 5 inches [13 cm] deep) with permanent flow on cobble-boulder substrates. Spire snails live on and under rocks and vegetation in</p>

Common Name	Scientific Name	Water Resource Inventory Area ^a	Tidal Reference Area ^b	Habitat Requirements and Reproduction Timing
				<p>the slow to rapid currents of streams where they graze on algae and small crustaceans.</p> <p>Reproduction/Life History</p> <p>They are short-lived, usually reaching sexual maturity within a year, at which time they breed and die. Unknown reproduction timing.</p> <p>(Neitzel and Frest 1989; Neitzel and Frest 1990; Pacific Biodiversity Institute 2007)</p>
California floater (mussel)	<i>Anodonta californiensis</i>	30, 36, 37, 40, 42, 47–49, 52–54, 58–61	NA	<p>General Information (Habitats and Feeding)</p> <p>In Washington, it is known to occur in the Columbia and Okanogan rivers and several lakes. Freshwater filter feeder requiring clean, well-oxygenated water for survival that is declining throughout much of its historical range. California floater mussels are intolerant of habitats with shifting substrates, excessive water flow fluctuations, or seasonal hypoxia.</p> <p>Reproduction/Life History</p> <p>Spring spawning occurs after adults reach 6–12 years in age. Fertilization takes place within the brood chambers of the female mussel. Fertilized eggs develop into a parasitic stage called glochidia, which attach to species-specific host fish during metamorphosis. After reaching adequate size, juvenile mussels release from the host and attach to gravel and rocks.</p> <p>(Box et al. 2003; Frest and Johannes 1995; Larsen et al. 1995; Nedeau et al. 2005; Watters 1999; WDNR 2006b)</p>
Western ridged mussel	<i>Gonidea angulata</i>	01, 03–05, 07–11, 13, 21–42, 44–55, 57–62	NA	<p>General Information (Habitats and Feeding)</p> <p>Specific information on this species is generally lacking; reside on substrates ranging from firm mud with the presence of some sand, silt, or clay to coarse gravel in creeks, streams, and rivers. They require constant, well-oxygenated flow, and shallow water (<10 ft [3 m] depth). This species may tolerate seasonal turbidity but is absent from areas with continuous turbidity and is sensitive to</p>

Common Name	Scientific Name	Water Resource Inventory Area ^a	Tidal Reference Area ^b	Habitat Requirements and Reproduction Timing
				<p>water quality changes such as eutrophication or presence of heavy metals.</p> <p>Reproduction/Life History</p> <p>During breeding, males release sperm into the water and females must bring this into their shell for fertilization to occur. Larvae called glochidia are released by the female and attach to the gills of fish for 1–6 weeks; postlarval mussels hatch from cysts as free-living juveniles to settle and bury in the substrate.</p> <p>(COSEWIC 2003; WDNR 2006b)</p>

Source: Modified from Jones & Stokes 2006.

a Water Resource Inventory Areas (WRIAs) are administration and planning boundaries for watershed areas, as established and managed by the Washington State Department of Ecology (Ecology). WRIA designations were formalized under WAC 173-500-040 and authorized under the Water Resources Act of 1971, Revised Code of Washington (RCW) 90.54. For WRIA boundary locations and related information, see URL = <http://www.ecy.wa.gov/services/gis/maps/wria/wria.htm>.

b Tidal Reference Areas as follows (from WAC 220-110-240): 1 = Shelton, 2 = Olympia, 3 = South Puget Sound, 4 = Tacoma, 5 = Seattle, 6 = Edmonds, 7 = Everett, 8 = Yokeko Point, 9 = Blaine, 10 = Port Townsend, 11 = Union, 12 = Seabeck, 13 = Bangor, 14 = Ocean Beaches, 15 = Westport, 16 = Aberdeen, 17 = Willapa Bay.

6 Conceptual Framework for Assessing Impacts

HPA-permitted activities can impact potentially covered species via a suite of potential mechanisms that affect organisms, their habitat, or critical ecological functions. Mechanisms of impact may be direct, such as causing bodily injury or mortality, or indirect, such as altering the habitats upon which these species depend for critical ecological functions (e.g., reproduction, rearing, migration, or refugia).

The identification of impact mechanisms associated with HPA-authorized activities that affect habitat was based on a model developed by Williams and Thom (2001). The conceptual model, presented below as Figure 6-1, provides a simple but effective characterization of the link between impacts and the ecological functions supported by the habitat.

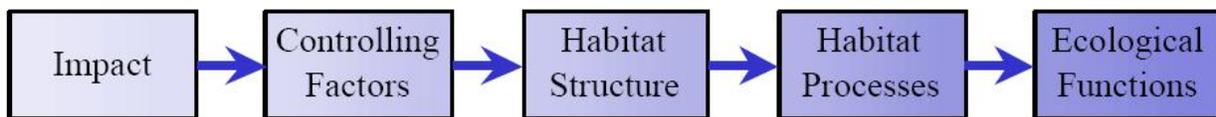


Figure 6-1. Conceptual Framework for Assessment

The Williams and Thom model provides the framework for analysis based on the literature search; in this white paper, our goals for using this framework are to:

- Elucidate impacts associated with each HPA activity
- Determine how those impacts manifest themselves in impacts on habitat and habitat functions utilized by the species that will be addressed in the HCP
- Develop recommendations for impact avoidance, minimization, and mitigation measures that target the identified impacts.

The analysis begins with an impact. An **impact** is defined as an unnatural disturbance to habitat-controlling factors. The impact will exert varying degrees of effect on controlling factors within the ecosystem (Williams and Thom 2001). **Controlling factors** are physical processes or environmental conditions such as light, temperature, salinity, stream or wave energy, substrate, water quality parameters, flow conditions, littoral drift, or channel geomorphology. These controlling factors determine various aspects of habitat structure. **Habitat structures** are the physical attributes of a habitat, for example, substrate type, aquatic vegetation, riparian vegetation or channel width. Habitat structure is linked to habitat processes. **Habitat processes** are defined as the dynamic biogeochemical, biologic, and physical processes which occur within a given aquatic habitat (e.g., shading, cover, sediment trapping, primary production), which are linked to **ecological functions** such as refuge and prey production.

As Williams and Thom (2001) describe the conceptual model, “Controlling factors are physical processes or environmental conditions that control local habitat structure and composition (e.g.,

vegetation, substrate), including where habitat occurs and how much is present. In turn, habitat structure is linked to support [habitat] processes, such as shading or cover, which are linked to ecological functions. Thus, impacts that affect controlling factors within an ecosystem will be reflected in changes to habitat structure, and will ultimately be manifested as changes to functions supported by the habitat. The effect at the functional level depends upon the level of disturbance and the relative sensitivity of the habitat to the disturbance.”

Two examples:

- The habitat structure provided by shoreline overhanging vegetation can provide shade for species using nearshore shallow water and upper beach habitats. This shade serves the ecological function of regulating temperature and supporting the food web through organic litter and insect input.
- The habitat structure of a riparian floodplain will engender increased autotrophy (a habitat process). Subsequently, increased autotrophy serves the ecological function of providing more food resources for fish and invertebrates.

These linkages form the **impact pathway**. Along the impact pathway, alterations to the environment associated with HPA-authorized activities can lead to impacts on the ecological function of the habitat used by HCP species. Impacts can often be viewed as stressors to the environment. Stressors primarily act at the level of the controlling factors. For example, shading from an overwater structure affects the controlling factor *light*, which in turn affects the growth and community structure of aquatic plants that comprise the habitat structure. In certain instances, stressors can act at the ecological function level. For example, overfishing can result in an altered number of prey resources associated with a habitat. **Mechanisms of impact** are the alterations to any of the conceptual framework components along the impact pathway that can result in an impact on ecological function and therefore on HCP species. For each type of HPA-authorized activity, several principal mechanisms of impact were identified for each subactivity type, from a geomorphological, engineering, hydrologic, and biological perspective.

This impact analysis helped to identify the direct and indirect impacts that could potentially affect federally listed species and those species that will be addressed in the HCP.

Table 6-1 identifies the mechanisms of impact that are known to be associated with various activities that are subject to HPA permits. By identifying these impacts and the nature of the risks these impacts exert on HCP species, measures can be implemented to avoid and, if avoidance is not possible, minimize harmful impacts on these species and the habitats that support their growth and survival.

Table 6-1. Mechanisms of impact associated with various HPA-permitted activities.

	Mechanism of impact	Water crossings	Fish passage	Flow control structures	Bank protection	Shoreline modifications	Channel modifications	Habitat modifications	Overwater structures	Marinas and terminals	Fish screens
Construction, Maintenance, Operations	Increased noise (pile driving, vessels)	x	x	x	x	x	x	x	x	x	x
	Filling and dredging	x	x	x	x	x	x		x	x	x
	Work area dewatering	x	x	x	x	x	x	x	x	x	x
	Grounding, anchoring, propwash						x		x	x	
	Ambient light modification						x		x	x	
	Entrainment, impingement, handling	x	x	x			x		x	x	x
Hydraulic and Geomorphic	Altered wave energy				x	x	x	x	x	x	
	Altered current, flow velocities	x	x	x	x	x	x		x	x	x
	Altered nearshore circulation				x	x	x	x	x	x	
	Altered groundwater/surface water/hyporheic exchange	x	x	x	x	x	x	x	x	x	
	Altered sediment supply, transport, littoral drift			x	x	x	x	x	x	x	

	Mechanism of impact	Water crossings	Fish passage	Flow control structures	Bank protection	Shoreline modifications	Channel modifications	Habitat modifications	Overwater structures	Marinas and terminals	Fish screens
	Altered substrate composition	X	X	X	X	X	X	X	X	X	X
	Altered channel processes and geometry	X	X	X	X	X		X	X	X	X
	Altered hydrologic regime from stormwater								X	X	
Riparian Vegetation	Altered shading, solar input, and air temperature	X	X	X	X	X	X	X	X	X	X
	Altered streambank and shoreline stability	X	X	X	X	X	X	X	X	X	X
	Altered allocthonous inputs, including large woody debris	X	X	X	X	X	X	X	X	X	X
	Altered groundwater/surface water/hyporheic exchange	X	X	X	X	X	X		X	X	X
	Altered habitat complexity, including from construction	X	X	X	X	X	X	X	X	X	X

	Mechanism of impact	Water crossings	Fish passage	Flow control structures	Bank protection	Shoreline modifications	Channel modifications	Habitat modifications	Overwater structures	Marinas and terminals	Fish screens
Aquatic Vegetation	Altered autochthonous production	x	x	x	x	x	x	x	x	x	
	Altered habitat complexity	x	x	x	x	x	x	x	x	x	
Water Quality (including construction, operation and maintenance impacts)	Altered temperature	x	x	x	x	x	x	x			
	Altered dissolved oxygen	x	x	x	x	x	x	x	x	x	
	Altered pH	x	x	x	x	x			x	x	x
	Altered salinity			x		x					
	Altered suspended solids and turbidity, including from construction	x	x	x	x	x	x	x	x	x	x
	Altered nutrient and pollutant loading: eutrophication	x	x	x	x	x	x	x	x	x	
	Altered pollutant loading to sediment and water column: organic contaminants including creosote					x	x			x	x
	Altered pollutant loading to sediment and water column: metals (ACZA/CCA)	x	x	x	x	x	x			x	x

	Mechanism of impact	Water crossings	Fish passage	Flow control structures	Bank protection	Shoreline modifications	Channel modifications	Habitat modifications	Overwater structures	Marinas and terminals	Fish screens
Ecosystem Fragmentation	Altered longitudinal connectivity and fish passage	x	x	x			x	x			x
	Altered lateral connections between rivers and floodplains		x	x	x	x	x	x			
	Altered habitat complexity	x	x	x	x	x	x	x			x

List of subactivity types for activities included in table 6-1:

- Water crossings
(bridges, culverts, conduits)
- Fish passage
(fish ladders, culverts, weirs, roughened channels, trap and haul)
- Flow control structures
(dams, weirs, dikes, levees, tide gates, intakes, outfalls)
- Bank protection/stabilization
(bulkheads, retaining walls, revetments, toe protection, beach nourishment, subsurface drainage, biotechnical bank protection, bank reshaping or regrading, soil reinforcement, coir and straw logs, integrated approaches.)
- Shoreline modifications
(groins, jetties, breakwaters)
- Channel modifications
(dredging, gravel mining and bar scalping, sediment capping, channel creation and alignment)
- Habitat modification
(beaver dam removal, large woody debris manipulations, spawning substrate augmentation, riparian planting, wetland creation/restoration, enhancement, beach nourishment/contouring, reef creation, eelgrass planting/restoration/enhancement, in-channel and off-channel habitat modifications)
- Overwater structures
(docks, floats, piers, ramps, wharfs, pilings and non-structural pilings)
- Marinas and Terminals
- Fish screens
(in-channel, off channel)

To further refine the analysis in each white paper, the exposure-response model (National Conservation Training Center 2004) was incorporated into the impact analysis. The exposure-response model evaluates the likelihood that adverse effects may occur as a result of species exposure to one or more stressors. This model takes into account the effects of exposure for all life-history forms likely to experience stressor exposure, and characterizes the resultant effects across all life-history stages.

The exposure-response model was incorporated as a series of matrices, presented in Appendix A, with results synthesized in Sections 7 and 9 (*Direct and Indirect Impacts* and *Potential Risk of Take*, respectively) of this white paper. In these species-specific exposure-response matrices, each mechanism and submechanism was initially examined and evaluated to:

- Identify and characterize specific impacts or stressors (i.e., nature and magnitude)
- Evaluate the potential for exposure (potential for species to be exposed = stressor timing/duration/frequency coincident with habitat use by the various life-history forms of the species in question)
- Identify the species' anticipated response to stressor based on the exposure parameters and life-history specific sensitivity
- Identify measures that could reduce exposure
- Identify performance standards if appropriate
- Characterize the resulting effects of specific impacts on the various species.

With regard to exposure, standard language was used to indicate when an impact occurs, for how long, and how frequently the stressor or impact occurs; definitions of these terms used in the analysis are listed in Table 6-2.

Based on life-history information, an analysis of potential exposure was completed for each species. This included an analysis of the direct and indirect impacts (associated with each of the impact mechanisms) on the different lifestages of each species and likely responses of the species to these stressors. Impact minimization measures to reduce or avoid submechanism impacts were identified. A final conclusion regarding overall effect of the submechanism/stressor on the species is also presented in Appendix A. Where information was available, the cumulative effects associated with the major impact mechanisms were also identified (see Section 8 [*Cumulative Effects*]).

The information generated by the exposure-response analysis is used to summarize the overall risk of take associated with the impact mechanisms produced by each subactivity type. The summary risk of take analysis is presented in Section 9 (Potential Risk of Take), which presents the risk of take associated with each subactivity type using: (1) a narrative discussion of the risk of take associated with each subactivity type by the specific associated submechanism of impact; and (2) risk of take assessment matrices that rate the risk of take

resulting from each subactivity by impact mechanism and environment type. The risk of take ratings presented in the text and matrices in Section 9 are based on the rating criteria defined in Table 6-3.

This method of risk of take analysis helped identify specific thresholds associated with each of the impacts beyond which take will occur. Summary tables were prepared to indicate the potential for take by species for each major impact mechanism (Section 9, *Potential Risk of Take*).

Based on the identification of impacts and risk of take analysis, additional recommendations (e.g., conservation, management, protection, BMPs) for minimizing or avoiding project impacts or risk of take were developed and presented in Section 11. [*Habitat Protection, Conservation, Mitigation, and Management Strategies*.]

Table 6-2. Definitions of terms used in the exposure-response analysis for this white paper.

Parameter	Description	Exposure	Definition
When	The timing during which stressor exposure occurs (e.g., time of day, season, associated with activity)	-	Defined flexibly as appropriate for each stressor.
Duration	The length of time the receptor is expected to be exposed to the stressor	Permanent	Stressor is permanent (e.g., conversion of habitat to built environment)
		Long-term	Stressor will last for greater than five years to decades (e.g., time required for complete riparian recovery)
		Intermediate-term	Stressor will last from 6 months to approximately 5 years (e.g., time required for beach substrate to recover from construction equipment)
		Short-term	Stressor will last from days to 6 months (e.g., time required for invertebrate community to recolonize following dewatering)
		Temporary	Stressor associated with transient action (e.g., pile driving noise)

Parameter	Description	Exposure	Definition
Frequency	The regularity with which stressor exposure is expected to occur and/or the time interval between exposure	Continuous	Stressor is ongoing and occurs constantly (e.g., permanent modification of habitat suitability)
		Intermittent	Stressor occurs routinely on a daily basis
		Daily	Stressor occurs once per day for extended periods (e.g., daytime structural shading)
		Common	Stressor occurs routinely (i.e., at least once per week or several times per month)
		Seasonal	Stressor occurs for extended periods during specific seasons (e.g., temperature effects occurring predominantly in winter and summer)
		Annual	Stressor occurs for annually for a short period of time
		Interannual–decadal	Stressor occurs infrequently (e.g., pile driving associated with project construction and maintenance)

Table 6-3. Definitions of the terminology used for risk of take determinations.

Risk of Take Code	Potential for Take	Definition
H	High	Stressor exposure is likely to occur with high likelihood of individual take in the form of direct mortality, injury, and/or direct or indirect effects on long-term survival, growth, and fitness potential due to long-term or permanent alteration of habitat capacity or characteristics. Likely to equate to a Likely to Adversely Affect (LTAA) finding.
M	Moderate	Stressor exposure is likely to occur causing take in the form of direct or indirect effects potentially leading to reductions in individual survival, growth, and fitness due to short-term to intermediate-term alteration of habitat characteristics. May equate to an LTAA or a Not Likely to Adversely Affect (NLTA) finding depending on specific circumstances.
L	Low	Stressor exposure is likely to occur, causing take in the form of temporary disturbance and minor behavioral alteration. If that take is insignificant or discountable, it would equate to an NLTA finding.
I	Insignificant	Stressor exposure may potentially occur, but the likelihood is discountable and/or the effects of stressor exposure are insignificant. Likely to equate to an NLTA finding.
N	No Risk	No risk of take ratings apply to species with no likelihood of stressor exposure because they do not occur in habitats that are suitable for the subactivity type in question, or the impact mechanisms caused by the subactivity type will not produce environmental stressors.
?	Unknown	Unknown risk of take ratings apply to cases where insufficient data are available to determine the probability of exposure or to assess stressor response.