Section 5

Status of the Species

This section describes the biology and distribution of the proposed, threatened, and endangered species occurring within the Seattle action areas (see Figure 1):

- Puget Sound Chinook salmon — Threatened
- Coastal-Puget Sound bull trout — Threatened
- Killer whale: Southern Resident — Endangered
- Steller sea lion: North Pacific population — Threatened
- Humpback whale — Endangered
- Marbled murrelet — Threatened
- Puget Sound steelhead — Threatened
- Eulachon – Threatened
- Bocaccio – Endangered
- Canary rockfish – Threatened
- Yelloweye rockfish – Threatened

The action areas for this Seattle Biological Evaluation are the 7 major drainage basins within Seattle (see Figure 1):

1. Elliott Bay
2. Lake Washington Ship Canal
3. Lower Green/Duwamish
4. North Seattle/Puget Sound
5. North Lake Washington
6. South Seattle/Puget Sound
7. South Lake Washington

The action areas are based on which waterbody surface waters will drain. Figure 2 shows the receiving waterbodies within the City of Seattle. The areas shown in white drain only to a sewage treatment plant. During high rain events within the white areas, discharges may occur from several combined sewer outfalls (CSOs) throughout the different action areas.

Before the potential effects of the proposed actions can be analyzed, it is important to understand how the species currently use the action areas. ‘Action area’ refers to the area affected by the actions covered in the Seattle Biological Evaluation. There are 7 action areas for the Seattle Biological Evaluation, and they are termed the ‘Seattle action areas’ in this document (see Figure 1). Of the listed species, the Chinook salmon, bull trout, steelhead, and killer whale reside in the Seattle action areas. The humpback whale, Steller sea lion, and marbled murrelet do not inhabit the Seattle action areas, but an occasional migratory animal may be observed. The use of the action areas by the eulachon, bocaccio, canary rockfish, and yelloweye rockfish, is rare or infrequent with some migratory use through the area. Table 5-1 summarizes the status of the listed species within the Seattle action areas.

Fig 2. Seattle Biological Evaluation Receiving Surface Waterbodies

11x17 inches

Table 5-1
Summary status of the species for Seattle action areas (Consult a scientist for the latest information.)

Species	Action areas	Species in system	Critical Habitat
Puget Sound **Chinook salmon** ***Oncorhynchus tshawytscha*** **Threatened** 	Ship Canal, North Lake Washington, and South Lake Washington	2 populations: • Sammamish River • Cedar River	Lake Washington and Ship Canal
	Lower Green/Duwamish	1 population: Duwamish/Green River	Duwamish River
	Estuarine and marine waters of Puget Sound including action areas of Elliott Bay, North Seattle/Puget Sound and South Seattle/Puget Sound	Puget Sound Chinook salmon from throughout ESU may be present in marine and estuarine waters	Inshore marine nearshore: MHHW, including tidally influenced freshwater heads of estuaries. Offshore marine nearshore extends from extreme high water out to a depth no greater than 98 ft (30 m) relative to MLLW
Coastal-Puget Sound bull trout *Salvelinus confluentus* Threatened 	Ship Canal, North Lake Washington, and South Lake Washington	Bull trout from throughout DPS may be present in Lake Washington and Ship Canal action area	Lake Washington and Ship Canal
	Lower Green/Duwamish	Bull trout from throughout DPS may be present in Lower Green/Duwamish action area.	Duwamish River
	Estuarine/marine waters of Puget Sound including action areas: Elliot Bay, North Seattle/Puget Sound and South Seattle/Puget Sound	Bull trout from throughout DPS may be present in marine and estuarine waters	Inshore marine nearshore: MHHW line, including tidally influenced freshwater heads of estuaries Offshore marine nearshore: extent of photic zone 33 ft (10 m)
Killer whale ***Orcinus orca*** **Endangered** 	North Seattle/Puget Sound, Elliott Bay, and South Seattle/Puget Sound	Southern Resident: particularly J Pod, but all pods use Puget Sound.	Designated habitat includes all waters in Puget Sound deeper than 20 ft (6.1 m)

Table 5-1
Summary status of the species for Seattle action areas (Consult a scientist for the latest information.)

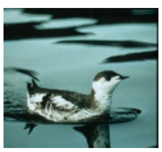
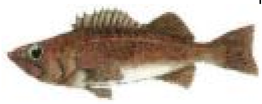
Species	Action areas	Species in system	Critical Habitat
Humpback whale ***Megaptera novaeangliae*** **Endangered** 	North Seattle/Puget Sound, Elliott Bay, and South Seattle/Puget Sound	Occurrence is rare, but species may migrate through action area.	No critical habitat has been designated for the humpback whale
Marbled murrelet ***Brachyramphus marmoratus*** **Threatened** 	North Seattle/Puget Sound, Elliott Bay, and South Seattle/Puget Sound	Occurrence is rare, but species may be present foraging in area.	No critical habitat has been designated within the Seattle action areas. 99.8% of designated critical habitat is located on federal lands in upper portions of watersheds. Marine environments were not designated
Puget Sound steelhead ***Oncorhynchus mykiss*** **Threatened** 	Ship Canal, North Lake Washington, South Lake Washington	4 spawning populations: Lake Washington, Cedar River, Lake Sammamish, Sammamish River	None proposed at this time
	Lower Green/Duwamish	2 stocks: Summer run, winter run	Proposed January 14, 2013.
	Estuarine and marine waters of Puget Sound	Steelhead throughout DPS may be present in marine and estuarine waters	Proposed January 14, 2013
Eulachon ***Thaleichthys pacificus*** **Threatened** 	North Seattle/Puget Sound, Elliott Bay, and South Seattle/Puget Sound	Occurrence is rare, but species may migrate through action area.	Proposed critical habitat does not include any of the Seattle action areas.

Table 5-1 **Summary status of the species for Seattle action areas (Consult a scientist for the latest information.)**			
Species	**Action areas**	**Species in system**	**Critical Habitat**
Bocaccio ***Sebastes paucispinis*** **Endangered** 	North Seattle/Puget Sound, Elliott Bay, and South Seattle/Puget Sound	Adults, juveniles, and larvae could be present.	Nearshore - Extreme high tide to a depth of 30 m (98 ft). Deepwater – depths greater than 30 m (98 ft).
Canary Rockfish ***Sebastes pinniger*** **Threatened** 	North Seattle/Puget Sound, Elliott Bay, and South Seattle/Puget Sound	Adults, juveniles, and larvae could be present.	Nearshore - Extreme high tide to a depth of 30 m (98 ft). Deepwater – depths greater than 30 m (98 ft).
Yelloweye Rockfish ***Sebastes ruberrimus*** **Threatened** 	North Seattle/Puget Sound, Elliott Bay, and South Seattle/Puget Sound	Adults and larvae could be present	Deepwater – depths greater than 30 m (98 ft).

5.1 Puget Sound Chinook Salmon

5.1.1 Listing and Critical Habitat Designation

Chinook salmon (*Oncorhynchus tshawytscha*)

were designated threatened on March 24, 1999 (64 FR 14307). The threatened status was reaffirmed on June 28, 2005 (70 FR 37160). Chinook salmon are Pacific salmon and belong to the scientific family Salmonidae. The ESA allows listing of 'distinct population segments' (DPS) of vertebrates. For a group of salmon populations to be a DSP they must be an evolutionarily significant unit (ESU). Scientists have established 2 criteria for ESUs:

1. The population must show substantial reproductive isolation
2. There must be an important component of the evolutionary legacy of the species as whole.

The Puget Sound ESU is comprised of 31 historically quasi-independent populations of Chinook salmon, of which 22 are believed to be existing (PSTRT 2001, 2002, Good et al. 2005). The populations presumed to be extinct were mostly early-returning fish. Most of these were in the mid- to southern parts of Puget Sound, Hood Canal and the Straits of Juan de Fuca.

The Puget Sound ESU encompasses all runs of Chinook salmon in the Puget Sound region from the North Fork Nooksack River to the Elwha River on the Olympic Peninsula. Chinook salmon are found in most rivers in this region. The boundaries of the Puget Sound ESU correspond generally with the boundaries of the Puget Lowland Ecoregion. Despite being in the rain-shadow of the Olympic Mountains, the river systems in this area maintain high flow rates due to melting snowpack in the Cascade Mountains. The Elwha River, which is in the Coastal Ecoregion, is the only system in this ESU that lies outside the Puget Sound Ecoregion. Previous assessments of stocks within the Puget Sound ESU have identified several stocks as being 'at risk' or 'of concern.' Long-term trends (~1952 to 2002) in abundance and median population growth rates for naturally spawning populations of Chinook salmon in Puget Sound indicate that about half of the populations are declining, and half are increasing in abundance (Good et al. 2005). Four of 22 populations have declining abundance over the short term (1990 to 2002), but 11 populations show declining population growth rates when strays from hatchery salmon are incorporated into the analysis.

NMFS designated critical habitat for this ESU on September 2, 2005 (70 FR 52630). Critical habitat is defined in section 3 of the ESA as the following:

> *"(i) the specific areas within the geographical area occupied by a species, at the time it is listed in accordance with the ESA, on which are found those physical or biological features (I) essential to the conservation of the species, and (II) which may require special management considerations or protection; and (ii) specific areas outside the geographic area occupied by a species at the time it is listed, upon a determination that such areas are essential for the conservation of the species."*

'Conservation' is defined by the ESA as the use of all methods and procedures necessary to bring any endangered or a threatened species to the point at which the measures provided under the ESA are no longer necessary.

To be included in a critical habitat designation, habitat must be ‘essential to the conservation of the species.’ Critical habitat designations identify, to the extent known and using the best scientific data available, habitat areas that provide at least 1 physical or biological feature essential to the conservation of the species. These physical or biological features are known as ‘primary constituent elements’ (PCEs) as defined by 50 CFR 424.12(b).

Critical habitat boundaries for Puget Sound Chinook salmon include stream channels within the designated stream reaches, and include a lateral extent as defined by the OHW (33 CFR 319.11).

Figure 3 shows the designated critical habitat areas for Puget Sound Chinook salmon, Coastal- Puget Sound bull trout and Southern Resident killer whale within City of Seattle boundaries.

In areas where OHW has not been defined, the lateral extent of critical habitat will be defined by the bankfull elevation. Bankfull elevation is the level at which water begins to leave the channel and move into the floodplain. The bankfull level is reached at a discharge that generally recurs at an interval of 1 to 2 years on the annual flood series. Critical habitat in lake areas is defined by the perimeter of the waterbody as displayed on standard 1:24,000 scale topographic maps or the elevation of OHW, whichever is greater. In estuarine and nearshore marine areas, critical habitat includes areas contiguous with the shoreline from the line of extreme high water out to a depth no greater than 98 feet (30 m) relative to MLLW.

The following are the 6 primary constituent elements (PCEs) for **Puget Sound Chinook salmon ESU critical habitat**:

- **Puget Sound Chinook Salmon PCE #1**: Freshwater spawning sites with water quantity and quality conditions and substrate supporting spawning, incubation and larval development. There are no freshwater spawning sites within the Seattle action areas.

Figure 3. Critical Habitat for Puget Sound Chinook salmon, Coastal-Puget Sound bull trout and Southern Resident killer whale around the City of Seattle

11x17 inches

- **Puget Sound Chinook Salmon PCE #2**: Freshwater rearing sites with water quantity and floodplain connectivity to form and maintain physical habitat conditions and support juvenile growth and mobility; water quality and forage supporting juvenile development; and natural cover such as shade, submerged and overhanging large wood, log jams and beaver dams, aquatic vegetation, large rocks and boulders, side channels and undercut banks.
- **Puget Sound Chinook Salmon PCE #3**: Freshwater migration corridors free of obstruction with water quantity and quality conditions and natural cover such as submerged and overhanging large wood, aquatic vegetation, large rocks and boulders, side channels, and undercut banks supporting juvenile and adult mobility and survival.
- **Puget Sound Chinook Salmon PCE #4**: Estuarine areas free of obstruction and excessive predation with water quality, water quantity, and salinity conditions supporting juvenile and adult physiological transitions between fresh- and saltwater; natural cover such as submerged and overhanging large wood, aquatic vegetation, large rocks and boulders, and side channels; and juvenile and adult forage, including aquatic invertebrates and fish, supporting growth and maturation.
- **Puget Sound Chinook Salmon PCE #5**: Nearshore marine areas free of obstruction with water quality and quantity conditions and forage, including aquatic invertebrates and fish, supporting growth and maturation; and natural cover such as submerged and overhanging large wood, aquatic vegetation, large rocks and boulders, and side channels.
- **Puget Sound Chinook Salmon PCE #6**: Offshore marine areas with water quality conditions and forage, including aquatic invertebrates and fish, supporting growth and maturation.

NMFS has analyzed habitat areas within 61 occupied watersheds in 15 associated subbasins, as well as the nearshore marine areas in Puget Sound (Table 5-2).

Table 5-2

Designated critical habitat subbasins for Puget Sound Chinook salmon

Nooksack	Upper Skagit	Sauk
Lower Skagit	Stillaguamish	Skykomish
Snoqualmie	Snohomish	Lake Washington
Duwamish	Puyallup	Nisqually
Skokomish	Hood Canal	Dungeness/Elwha
Nearshore marine areas		

5.1.2 Species Information

5.1.2.1 Life History

Chinook salmon have a complex lifecycle that spans a variety of fresh and saltwater habitats. They are anadromous fish, which means that they migrate up rivers from the ocean to breed in freshwater. Pacific salmon are in the scientific genus *Oncorhynchus*, which includes pink, sockeye, chum, Chinook and coho salmon, steelhead, and rainbow trout. Salmon fry emerge from spawning gravels in inland streams and rivers, migrate to coastal estuaries, and then disperse into ocean waters to grow. Once mature, they reverse their course, returning through the estuaries, fighting their way back upriver to the very streams where they emerged, to reproduce, die, and begin the cycle again.

The largest of any salmon (Netboy 1958), Chinook salmon exhibit the most complex life history strategies of all salmonids. Healey (1986) described 16 age categories for Chinook salmon, 7 total ages with 3 possible freshwater ages. Two generalized freshwater life-history types were initially described by Gilbert (1912):

- **Stream-type** Chinook salmon that reside in freshwater for a year or more following emergence
- **Ocean-type** Chinook salmon that migrate to the ocean within their first year.

Healey (1983, 1991) has promoted the use of broader definitions for ocean-type and stream-type to describe 2 distinct races of Chinook salmon. This approach incorporates life-history traits, geographic distribution, genetic differentiation, and gives a frame of reference for comparisons of Chinook salmon populations. The generalized life history of Chinook salmon involves incubation, hatching, and emergence in freshwater, migration to the ocean, and subsequent initiation of maturation and return to freshwater for completion of maturation and spawning.

Spring-run Chinook salmon in the Puget Sound ESU typically have a high proportion of yearling smolt emigrants. Summer- and fall-run Chinook salmon typically smolt as subyearlings, but some systems produce yearling smolts. Year-to-year variations in smolt age are likely determined by variations in environmental conditions, whereas mean age of smolts is likely determined by genetic factors. Summer and fall runs tend to mature at ages 3 and 4 and exhibit similar, coastally-oriented, ocean migration patterns.

The most recent 5-year geometric mean natural spawner numbers in populations of Puget Sound Chinook salmon range from 222 to 9,489 fish (Good et al. 2005). Most populations contain hundreds of natural spawners (median recent natural escapement = 766). Of the 10 Puget Sound Chinook salmon populations with more than 1,000 natural spawners, only 2 are thought to have a low fraction of hatchery fish. Estimates of historical equilibrium abundance, from pre-settlement habitat conditions, range from 1,700 to 51,000 potential Chinook salmon spawners per population.[1] The historical estimates of spawner capacity are several orders of magnitude higher than realized spawner abundances currently observed throughout the Puget Sound ESU (Good et al. 2005).

[1] Equilibrium abundance is the abundance on a recruitment curve where recruitment of adults equals the number of parents that produced them. Continual spawning levels that achieve equilibrium abundances are high and by definition cannot support salmon fisheries (lower spawning escapements lead to less competition, higher survival rates, and a potential to support fisheries).

5.1.2.2 Factors for Decline

Factors for decline include human activities that have blocked or reduced access to historical spawning grounds and altered downstream flow and thermal conditions. In general, upper tributaries have been impacted by forest practices while lower tributaries and mainstem rivers have been influenced by agriculture and urbanization. Diking for flood control, draining and filling of freshwater and estuarine wetlands, and sedimentation due to forest practices and urban development are cited as problems throughout the ESU (WDF et al. 1993). Blockages by dams, water diversions, and shifts in flow regime due to hydroelectric development and flood control projects are major habitat problems in several basins. Bishop and Morgan (1996) identified a variety of critical habitat issues for streams in the Puget Sound ESU range:

1. Changes in flow regime (all basins)
2. Sedimentation (all basins)
3. High temperatures in some streams
4. Streambed instability
5. Estuarine loss
6. Loss of large woody debris in some streams
7. Loss of pool habitat in some streams
8. Blockage or passage problems associated with dams or other structures
9. Decreased gravel recruitment.

These impacts on the spawning and rearing environment may also have had an effect on the expression of many life-history traits and masked or exaggerated the distinctiveness of many stocks. The Puget Sound Salmon Stock Review Group (PFMC 1997) concluded that reductions in habitat capacity and quality have contributed to low survival and abundance of Puget Sound Chinook salmon. It cited evidence of direct losses of tributary and mainstem habitat due to the following:

- Dams
- Loss of slough and side-channel habitat caused by diking, dredging, and hydromodification
- Reductions in habitat quality due to land management activities.

The artificial propagation of fall-run stocks is widespread throughout this region. Summer/fall Chinook salmon transfers between watersheds within and outside the region were commonplace during the early to mid-1900s. Chinook salmon originating from the Green River hatchery were commonly planted in many watersheds in Puget Sound, especially south Puget Sound streams. Nearly 2 billion Chinook salmon have been released into Puget Sound tributaries since the 1950s. Most of these have been from local returning fall-run adults. Returns to hatcheries have accounted for 57% of the total spawning escapement. However, the hatchery contribution to spawner escapement is probably much higher due to hatchery-derived strays on the spawning grounds. The electrophoretic (physical-chemical) similarity between Green River fall-run Chinook salmon and several other fall-run stocks in Puget Sound suggests a significant and lasting effect from some hatchery transplants (Marshall et al. 1995). Overall, the pervasive use of

Green River stock throughout much of the extensive hatchery network in this ESU may reduce the genetic diversity and fitness of naturally spawning populations.

Nehlsen et al. (1991) identified 4 stocks as extinct, 4 stocks as possibly extinct, 6 stocks as at high risk of extinction, 1 stock as at moderate risk, and 1 stock of special concern. Harvest rates on Puget Sound Chinook salmon populations averaged 75% (median = 85%; range 31-92%) in the earliest 5 years of data availability and have dropped to an average of 44% (median = 45%; range 26-63%) in the most recent 5-year period (Good et al. 2005).[2]

Abundance of natural-spawning Chinook salmon in this ESU has declined substantially from historical levels. Many populations are small enough that genetic and demographic risks are likely to be relatively high. Both long- and short-term trends in abundance are mainly downward, and several populations are exhibiting severe short-term declines. Spring-run Chinook salmon populations throughout the Puget Sound ESU are all depressed.

Other concerns noted by NMFS's Biological Review Team, who drafted the status of the Chinook salmon populations, are the following:

- Concentration of most natural production of Chinook salmon are in just 2 basins (Skagit River and Snoqualmie River, including the Skykomish River)
- High levels of hatchery production in many areas of the ESU
- Widespread loss of estuary and lower floodplain habitat diversity and, likely, associated life-history types.

Populations in this ESU have not experienced the sharp increases in the late 1990s seen in many other ESUs, though more populations have increased than decreased since the last Biological Review Team assessment. Marine conditions are known to have a strong effect on survival of Puget Sound Chinook salmon (Mahnken et al. 1998, Ruggerone and Goetz 2004). After adjusting for changes in harvest rates, however, trends in productivity are less favorable. Most populations are relatively small. Recent abundance within the ESU is only a small fraction of estimated historic size.

5.1.2.3 Habitat Requirements

Chinook salmon require varied habitats during different phases of their lifecycle. Spawning habitat typically consists of riffles and the tailouts of pools with clean substrates dominated by gravel located in the mainstem of rivers and large tributaries (Cramer et al. 1999, Schuett-Hames and Pleus 1996). Chinook salmon are most frequently observed spawning in water with a daily average temperature ranging from 39º to 57º F (4-14º C). Juvenile Chinook salmon usually rear in water with temperatures ranging from 50º to 63º F (10-17º C) (USEPA 2003). Chinook salmon typically spend 1 to 5 months rearing in freshwater before migrating to the ocean, where they typically spend 1 to 6 years maturing. Chinook salmon may spend up to 1 year in freshwater when environmental conditions are not favorable for migration (Myers et al. 1998a).

Juvenile Chinook salmon require estuarine and nearshore marine habitat for migration, foraging, refuge, and osmoregulation processes (physiological transition to saltwater).

[2] The earliest 5 years of data vary with the 22 populations. The earliest data begin in 1969 (7 populations), 1971 (1 population), 1972 (3 populations), 1977 (1 population), 1979 (2 populations), 1981 (1 population), 1982 (3 populations), 1984 (2 populations), and 1985 (2 populations). The 5-year most recent period is 1994 – 1998 for all populations.

Juveniles spend from 1 to 6 weeks in estuarine habitat before migrating into marine waters (Williams et al. 2001, Ruggerone and Volk 2004). Juveniles rely on shallow nearshore habitats such as eelgrass meadows, intertidal flats, tidal marshes, and subtidal channels near estuaries (Steelquist 1992). Once juvenile Chinook salmon are large enough to eat small fish and have grown larger than most prey, they move away from shore into deeper marine waters.

Chinook salmon are opportunistic feeders. Juveniles prey on a wide variety of food such as benthic, epibenthic, and pelagic crustaceans, as well as insects, fish larva, and juvenile fish. While in the estuarine and marine environment, adult salmon feed on forage fish such as surf smelt, longfin smelt, Pacific sandlance and herring.

5.1.3 Species Occurrence in Action Areas

5.1.3.1 Lake Washington Ship Canal, North Lake Washington, South Lake Washington

The Lake Washington Ship Canal (Ship Canal), North Lake Washington, and South Lake Washington action areas are combined because they comprise the western portion of the Lake Washington basin. Designated critical habitat for these action areas includes Lake Washington and the Ship Canal. As defined by the Puget Sound Technical Recovery Team, 2 populations of the Puget Sound Chinook salmon ESU are present in the Lake Washington basin (Ruckelshaus et al. 2006):

1. Sammamish River population includes Issaquah Creek, a composite population at least partially sustained by production from the Issaquah hatchery, and north Lake Washington tributaries.
2. Cedar River population.

Current Range

Chinook salmon are found throughout Lake Washington and the Ship Canal. Within the tributaries of the Ship Canal, North Lake Washington, and South Lake Washington action areas, Chinook salmon are found only within Thornton Creek. Chinook salmon have been observed in the delta and lower reach of Taylor Creek. These fish may be juveniles migrating from the Cedar River and are using the shoreline habitat along the south end of Lake Washington (Tabor et al. 2006).

Migration

Several engineered changes within the Seattle action areas have had a profound impact on migration of the species. The City of Seattle has conducted recent detailed studies on the migration patterns of juvenile Chinook salmon. The following discussion reflects this wealth of information.

Engineered Changes within the Watershed

The Cedar River Chinook salmon population has been greatly affected by the construction of the Ship Canal. Built between 1911 and 1917, the Ship Canal rerouted the rivers that fed and drained Lake Washington forcing the Cedar River Chinook salmon juveniles to move into Lake Washington where they spend time rearing, then migrate through the Ship Canal, through the Hiram M. Chittenden Locks in Ballard (the Locks) and into Puget Sound (reverse order for spawning adults).

Before construction of the Ship Canal, Cedar River Chinook salmon migrated through the Cedar-Black-Green-Duwamish rivers for hundreds of generations, adapting to those circumstances. Cedar River Chinook salmon were forced into the new system almost instantly. Most Chinook salmon populations do not move through large lakes between freshwater spawning grounds and saltwater rearing habitat. As a result of the migration pathway reorientation and a lake in the new migratory pathway, Cedar River Chinook salmon stocks have remained at low levels for many generations.

Another consequence of the drainage system revision on Cedar River Chinook salmon survival is the lack of a brackish water transition zone. For most Chinook salmon stocks, the estuary is an especially important transition zone in the migration from fresh- to saltwater. The estuary provides essential resources such as food and salinity gradients that aid in the transition from fresh to saltwater habitats. In the Lake Washington basin, the estuary is extremely limited in Salmon Bay. Historically, Cedar River summer/fall Chinook salmon smolts migrated out through the Duwamish estuary. With the rerouting of the Cedar River into the Lake Washington in 1916, these smolts must migrate through Salmon Bay, an area where a much more rapid transition to saltwater occurs than that which these fish evolved under (Kerwin 2001). Both juvenile and adult individuals are forced to move abruptly from one salinity regime to another. The normal state of affairs would be for migrants (juveniles or adults) to spend time in the brackish water interface between salinity regimes (acclimation period) before moving from one salinity regime into another. This may well contribute to an increase in mortality.

Adult Migration

Adult Chinook salmon hold in Salmon Bay, west of the Locks, for an unknown period of time while acclimating to changes in salinity and temperatures (Taylor Associates 2010), or their success ascending the fish ladder (City of Seattle 2003). On average, adult Chinook salmon hold 19 days below the Locks, ranging from 1.0 to 45.0 days (Taylor Associates 2010) or 15 to 23.5 days (City of Seattle 2003). Approximately 30% of tagged adults that passed through the fish ladder moved back downstream below the Locks to return to cooler more saline waters (Taylor Associates 2010).

Adults first arrive at the Locks in mid-June. The peak time of entry through the Locks and into the Lake Washington basin occurs in mid-to late August and is generally complete by early November. These fish spend only 1 to 2 days migrating from the Locks to Lake Washington and take up temporary residence (days to 2 months) in Lake Washington before entering upstream spawning areas. Lake Washington basin summer/fall Chinook salmon stocks range in spawn timing from mid-September through November (Kerwin 2001).

Juvenile Migration

Juvenile Chinook salmon outmigration to Lake Washington and the estuary occurs over a broad time period. Typical juvenile summer/fall Chinook salmon outmigrate from January through early July. Two rearing strategies have been seen (Celedonia et al 2009). Fry enter Lake Washington from Jan through March and rear in the south end of Lake Washington for several months or fry rear in the river and then migrate to the lake in May or June as pre-smolts. Typically, the Lake Washington basin summer/fall Chinook salmon migrate within their first year of life. Some juveniles remain in the lake for an additional year. There are no data to indicate that there is a large component of Lake Washington basin stock summer/fall Chinook salmon juveniles remain in freshwater for that additional year after emerging from the redds. However, other Puget Sound Chinook salmon stocks (e.g., Snohomish summer Chinook salmon and Snohomish fall Chinook salmon) produce a significant number of juveniles that do remain in the freshwater environment for an additional year (Kerwin 2001).

Lake Washington and the Ship Canal provide rearing and foraging habitat for juvenile salmon in a variety of ways. Many Chinook salmon young-of-year use the lake for 1 to 5 months as rearing habitat before outmigration. Some (a small percentage) appear to stay for another year or 2 (DeVries 2005, Seiler et al. 2005). In years with larger winter and early spring flows, a large percentage of Chinook salmon fry may enter the lake from late January through April, followed by smolts. While rearing, juvenile Chinook salmon are shoreline oriented, using shallow water areas (< 3.2 feet or < 1m). When these fry reach a larger size, they disperse to deeper water (3.2 to 19.6 feet or 1 to 6 m) (Fresh 2000, Piaskowski and Tabor 2001, Tabor et al. 2006) and begin migration towards the Locks (Martz et al. 1996). Juvenile Chinook salmon spend between 2 to 4 weeks migrating through the Ship Canal (DeVries 2005). Most of the Ship Canal appears to function as a migratory corridor with Lake Union being a long-term holding area. Juveniles can spend days to weeks in Lake Union, utilizing the entire lake (Celedonia et al. 2009). Juveniles migrate past the Locks from May to September with peak migration occurring in June.

Seiler (1999) found that Chinook salmon preferred nighttime migration in the Cedar River and Bear Creek. For the first 4 weeks of trap operation, beginning January 23, weekly day/night ratios for Chinook salmon varied from 17% to 59% and declined as the season progressed. Juvenile migration is different in the river than it is in the lake. Juveniles rear in Lake Washington for 3 or more months. A comparison of the passage timing data with lunar data for Lake Washington and the Locks suggests a strong correlation between moon location relative to the earth and emigration timing, particularly for Chinook and coho salmon. This correlation appeared stronger than the correlation between emigration and moon phase (illumination). Migration through the Locks increased markedly within 1 or 2 days of the moon being at apogee (i.e., when the moon is farthest from the earth). Emigration decreased by the time of the next apogee (R2 Resource Consultants 2002). Peak Chinook salmon smolt outmigration occurs in June (Tabor et al. 2006).

Once through the Locks, juvenile Chinook salmon reside within Salmon Bay for a very short period of time compared to other estuaries (Taylor Associates 2010). Residence time varies from an hour to 31 days. This is compared to other estuaries where residence times can be up to 90 days. The difference may be to the larger size smolts that are leaving the Ship Canal and the Lake Washington system (Taylor Associates 2010).

Habitat Use

Tabor and Piaskowski (2002) and Tabor et al. (2003; 2004a, b; 2006) investigated nearshore habitat use of juvenile Chinook salmon, primarily in the littoral (intertidal) zone. They sampled locations on the west shore of Lake Washington between the Cedar River and Ship Canal, on Mercer Island and the eastern lake shoreline (12 sites total). Snorkel surveys were conducted between January and June when use by juvenile Chinook salmon typically occurs. Surveys found that numbers of juvenile Chinook salmon in the nearshore areas of south Lake Washington increased substantially in early March. During this time, fish concentrate in the south end of the lake near the mouth of the Cedar River and their numbers decline with increasing distance from the Cedar River (Tabor et al. 2004a, b; 2006). Behavior varies between night and day, with few fish observed during daytime surveys in April and May (Tabor and Piaskowski 2002). During the day, juvenile Chinook salmon were observed in aggregations (sometimes with sockeye), actively feeding at the surface. At night, Chinook salmon were no longer in an aggregation, were inactive, and were usually on the bottom in shallow water, close to shore (Tabor and Piaskowski 2002, Tabor et al. 2003; 2004a, b; 2006).

Habitat use by juvenile Chinook salmon varies somewhat between when they are fry (March-April) and larger smolts (May-June). The studies found that juvenile Chinook salmon fry preferred shallow depths, generally less than 1.6 feet (0.5m) deep, and areas with gradual slopes (Piaskowski and Tabor 2001, Tabor and Piaskowski 2002, Tabor et al. 2003; 2004a, b; 2006). By mid-May when fish are larger, they appear to move into deeper water. Sampling by Fresh (2000) found juvenile Chinook salmon expanding into the limnetic (open water of freshwater zone) of the lake. Water depth and migratory observations by Tabor et al. (2006) identified fish often feeding in water 6.5 to 13 feet (2-4 m) deep and migrating adjacent to the shoreline in these similar water depths 6.8 to 14.7 feet (2.1-4.5 m). Chinook salmon fry primarily selected sand, while later in May and June juveniles preferred both sand and gravel substrates. Coarser substrates such as cobble and boulders are used by very few fish and appear to be avoided.

More juvenile Chinook salmon are found along unretained shorelines than are found along armored shorelines (Paron and Nelson 2001, Piaskowski and Tabor 2001, Tabor and Piaskowski 2002, Tabor et al. 2004b, 2006). The fish used armored sites that were riprapped more than they used shorelines with a vertical bulkhead. Use of engineered overwater structures—such as docks and piers—seems to vary with fish size. Chinook salmon fry can use docks and piers during the daytime when the fry are small (February-March) (Tabor et al. 2003, 2004a). However, when fish grow larger, they avoid docks and piers and even alter migrational direction to move into deeper water as they approach docks and piers (Tabor and Piaskowski 2002; Tabor et al. 2004a; 2006).

Woody debris is generally more associated with higher overall densities of juvenile Chinook salmon than openwater sites during the daytime, with a reverse trend observed at night. In particular, a variety of different surveys from lakes Washington, Sammamish, and Quinault indicate that overhead cover is an important habitat feature for small Chinook salmon (Paron and Nelson 2001, Tabor et al. 2006). Results from overhead vegetation and in-water small woody debris studies conducted between late March and early April showed a significantly higher abundance of juvenile Chinook salmon during the daytime in sections with both overhead vegetation and small woody debris than sections with small woody debris or open sections (Tabor and Piaskowski 2002, Tabor et al. 2004b, 2006). However, at night, 46% of all the Chinook salmon were in open water. Of those, 65% were within areas with overhead vegetation/small woody debris and small woody debris located in the open. Previous work in Lake Washington also indicated Chinook salmon do not appear to extensively use cover as they increase in size (Tabor and Piaskowski 2002, Tabor et al. 2004a, 2006).

Studies in May, when Chinook salmon were larger, found that few Chinook salmon used overhead and small woody debris during either daytime or nighttime (Tabor and Piaskowski 2002, Tabor et al. 2004a, 2006). Field observations indicate that woody debris and overhanging vegetation can be used by juveniles as cover when predators are present (Tabor et al. 2006). Coho salmon exhibited similar use patterns in Lake Sammamish, and were more strongly affiliated with woody debris than were Chinook salmon.

As juvenile Chinook salmon migrate into the Ship Canal, they are no longer shoreline oriented and are broadly distributed throughout off-shore, deep water areas (Celedonia et al. 2009). This may be related to differences in predator populations and prey availability between Lake Washington and the Ship Canal. Fewer predators (northern pikeminnow and cutthroat trout) are found within the Ship Canal. Therefore, Chinook salmon can forage offshore where greater zooplankton abundance occurs.

Juvenile Chinook salmon in the Ship Canal also use edges of overwater structures in deep water, especially when water clarity is high. This may be due to increased offshore forage. However, this behavior may also result in increased predation from smallmouth bass that are oriented to overwater structures. Juvenile Chinook salmon were not found under the overwater structures (Celedonia et al. 2009).

Diet

Diet studies of Chinook salmon in Lake Washington and Lake Sammamish illustrate that juveniles are opportunistic feeders. Juvenile Chinook salmon consume a wide variety of prey items and appear to quickly switch to a locally abundant prey source (Tabor et al. 2006). Two major prey resources within Lake Washington are chironomids and a zooplankton, Daphnia. While Daphnia typically do not become abundant in the lake until June, chironomids are extremely abundant in the nearshore areas of Lake Washington most of the year (Koehler 2002). Tabor et al. (2006) examined the diet of juvenile Chinook salmon using lake shoreline reference sites and nearby lake tributaries to determine if there were differences in the prey consumed between these habitats. The studies found that there were not significant differences between Chinook salmon diets at the 2 types of sites and that chironomid pupae and adults were the most important prey item. This lack of a large difference between diets at lakeshores and tributary mouths is likely due to a prevalence of chironomid pupae and adults in the system, making them an important food source regardless of location. Benthic insects (chironomid larvae and mayfly nymphs) and terrestrial insects were more prevalent in Chinook salmon diets at tributary mouths than at lakeshore sites. In addition, occasionally some prey types (i.e., springtails, larval black flies and rhyacophilid caddisflies) were consumed at tributary mouth sites. In general, Chinook salmon diets at the tributary mouths had a wider variety than those at lakeshore sites (Tabor et al. 2006). In addition, Chinook salmon eating larval longfin smelt was documented at 1 tributary mouth (May Creek).

Thornton Creek

Thornton Creek within the North Lake Washington action area contains small numbers of Chinook salmon. Historically, Thornton Creek probably had Chinook in the mainstem, and perhaps the lower reaches of the forks (Trotter 2002). Washington Department of Fisheries (WDFW) salmon spawning ground surveys data had counts of 2 to 10 adults in 1976 and 1981. In addition, Thornton Creek received state releases of hatchery reared Chinook salmon on and off from 1977 to 1994, mostly from the University of Washington hatchery in Portage Bay (WDFW fish stocking records). The City of Seattle conducted salmon surveys in Thornton Creek from 1999 through 2008. During this time, 13 live Chinook salmon and 12 carcasses have been found in Thornton Creek (McMillan 2006, SPU 2009 unpublished data). Over half of these were identified as hatchery strays because of clipped adipose fins (McMillan 2006, SPU 2009 unpublished data).

Spawning within Thornton Creek occurs mainly downstream of the confluence of the North and South branches to Lake Washington. About 40 total Chinook salmon redds have been observed in Thornton Creek from 1999 to 2008 (McMillan 2006, SPU 2009, unpublished data). Of these, about one-third were located in the mainstem between the confluence and the outlet of the Meadowbrook Pond forebay (38th Avenue NE). Only a few were found in the forks, and more were found in the North Branch than found in the South Branch (McMillan 2006). In 2007, 16 Chinook redds were found within Thornton Creek, 9 within the mainstem, 6 in the North Branch, and one in the South Branch. In 2008, only 4 Chinooks were found in Thornton Creek, all in the mainstem.

The most upstream extent where Seattle Public Utilities spawning surveys have sighted Chinook salmon redds in Thornton Creek were downstream of the confluence of Kramer Creek at 30th Avenue NE on the South Branch, and upstream of NE 115th Street at 35th Ave NE on the North Branch (McMillan 2006, SPU 2009 unpublished data).

In 2002, a fish ladder was constructed to remove a 3-foot (0.9-m) fish barrier in South Branch Thornton Creek at Lake City Way. Since construction of the fish ladder, citizens have reported 2 sightings of Chinook salmon upstream of the fish ladder. One was on October 19, 2003, and another citizen photographed a live Chinook salmon just downstream of 20th Avenue NE on October 22, 2003. These sightings may have been the same fish. In addition, a King County/Salmon Watch member observed a Chinook salmon on October 25, 2004, at the juncture of 20th Avenue NE and NE 100th Street.

No information is available on emergent juvenile abundance (K. Lynch, SPU, pers. comm. 2004). However, starting in spring 2000, the City of Seattle, in cooperation with WDFW, conducted annual smolt trapping on Thornton Creek. The trapping survey is not comprehensive, and samples only part of the season. Typically, these surveys occurred during the first 2 weeks of May in an attempt to overlap with the peak outmigration period of coho smolts. The trapping period lasted 5 to 15 days per year, except in 2004 when the trapping period was 25 days. Between 2001 and 2003, coho smolts averaged about 5 to 10 per day. Since 2004, the average has dropped to less than 1 coho smolt per day. In most years, Chinook smolt captures are generally very low (0 to 2). However, in 2004, over 300 fish were captured (SPU smolt trapping data, K. Lynch, SPU, pers. comm. 2004). In 2004, the smolt trap results showed a different pattern: a higher number of Chinook salmon smolts (average of 12/day and 309 total), and very few coho (<1/day, 14 total) (SPU smolt trapping data). The trap was removed on May 25, 2004 to allow peamouth adults to move upstream to spawn. It is not known why 2004 results differed from the 2001 and 2003 data. One possibility was a warm spring in 2004, which might have caused Chinook salmon to emerge sooner than usual. The numbers were low for salmon smolts in 2005 and 2006: <1 coho /day, and only 1 Chinook in 2005 (none in 2006) (SPU smolt trapping data). Although the Salmon in the Classroom Program discontinued releasing hatchery salmon fry in 1999, other hatchery salmon releases may be occurring, which could affect the smolt trapping results.

Use of Non-Natal Tributaries

Studies indicate that juvenile Chinook salmon are attracted to non-natal tributaries in Lake Washington, using either the creek mouth or the lowest reaches of the tributary itself (Tabor et al. 2006). The use of non-natal tributaries is based on distance from the natal river and size, with larger creeks (e.g., Taylor Creek) likely avoided because of larger predatory fish in the area. Creek deltas offer preferred habitat, specifically shallow water, gradual slopes, and sand substrates (Tabor et al. 2004b). Creek deltas may also provide better foraging opportunities than adjacent lake shorelines. For example, Tabor et al. (2006) found that the abundance of Chinook salmon increased during a high flow event at May Creek, a tributary to Lake Washington. During storms, an increase in prey availability as well as flow may attract Chinook salmon and other salmonids such as cutthroat trout to lake tributaries.

In cases where Chinook salmon are using habitat within the tributary, use appears related to the ability to access the creek and find refuge and forage (Tabor et al. 2006). Habitat use studies within Johns Creeks, a tributary to Lake Washington close to the Cedar River mouth, found that Chinook salmon mostly used glides and scour pools (Tabor et al. 2004b, 2006). Fry density was greatest in glides during February and early March, but as the fish grew, the density of fish in glides dramatically declined. When fish were found in glides during late March and early April, they were almost always under overhanging vegetation. Scour pools were used throughout the February to May study period, with fish using shallow areas in February (edges and tailouts) and progressively moving into the deepest areas of the pools by the end of March. Scour pool densities were greatest April to May (Tabor et al. 2004b, 2006).

Drainages Outside of City Limits

The Sammamish and Cedar River populations all have declined since peak returns during the mid-1980s (Weitkamp et al. 2000). Adult returns have declined more than 8% per year for each run, with the Cedar River run declining at 10.1% per year, the Issaquah Creek run at 8% per year, and the North Lake Washington tributary run at 16.6% per year. Of the 23 populations of Chinook salmon in Puget Sound, the Lake Washington populations were among the 5 populations showing the steepest declines (>5%/yr) (Myers et al. 1998a; Good et al. 2005). Spawning escapements of natural Lake Washington Chinook salmon were exceptionally low in 1993 (approximately 150 fish) and in 2000 (approximately 100 fish) (White et al. 2008). The escapement goal for the Cedar River Basin is 1,200 fish.

5.1.3.2 Lower Green/Duwamish

Chinook salmon migrating through the Duwamish River estuary were initially divided into 2 main stocks (WDFW and WWTIT 1994): 1) the Duwamish/Green River summer/fall stock, and 2) the Duwamish/Green River-Newaukum Creek summer/fall stock. However, NMFS (70 FR 52630) considered these stocks to be a single independent population (Ruckelshaus et al. 2006).

Critical habitat extends from the estuary to the headwaters of the watershed, including tributaries known to support Chinook salmon. Critical habitat for this action area includes the Duwamish Waterway and the Duwamish River up to the city limit near river mile (RM) 4.6. The City of Seattle has been conducting salmon surveys in Longfellow Creek since 1999. Only 1 pair of Chinook salmon was recorded in Longfellow Creek in 2001, along with 1 possible Chinook salmon redd (McMillan 2006). The City of Seattle identified one live Chinook salmon in Longfellow Creek in 2003 (City of Seattle 2007).

Current Range

Spring Chinook salmon were historically present in the Green/Duwamish River basin. However, little information is available to evaluate the distribution of spring Chinook salmon in the watershed. It is possible the spring run was totally extirpated by the original construction effects of the Tacoma Headworks Dam in 1911, or became isolated from the basin by the diversion of the White River in 1906 (Kerwin and Nelson 2000).

Chinook salmon are presently distributed up to the Tacoma Headworks Dam (RM 61) and in several tributaries such as Soos and Newaukum creeks. The Muckleshoot Indian tribe release hatchery Chinook salmon fry into streams upstream of Howard Hanson Dam. Plans are being developed to transport adult salmon around the 2 dams and to enable juvenile fish passage through the dams.

Abundance and Productivity

The number of adult Chinook salmon spawning in the Green/Duwamish watershed averaged 9,286 fish during 1998 to 2002 (Good et al. 2005). The total number of adult Chinook salmon spawning ranged from 6,170 to 13,950 during the same period. However, a multi-year mark-recapture study indicated the spawning ground counts were biased low and the average number of spawners was 13,815 fish during 1998 to 2002. The estimated percentage of hatchery salmon on spawning grounds was 83% during 1997-2001 (Good et al. 2005), indicating only a small fraction of fish on the spawning grounds had originated from naturally spawning salmon.

Abundance of Chinook salmon includes fish returning to spawning areas plus those caught in fisheries. During the most recent 5-year period, about 57% of returning salmon were harvested in fisheries (Good et al. 2005). Thus, approximately 24,200 fish, on average, were destined for spawning areas of the Green River if fisheries had not occurred. Also, approximately 16,300 fish per year were destined for the hatchery. However, only a small portion of these fish were produced by naturally spawning salmon.

Good et al. (2005) estimated that the long- and short-term trends of naturally spawning Chinook salmon in the Green River are slightly positive. However, if the presence of numerous hatchery strays on the spawning grounds is included in the analysis, then the population growth rate is estimated to be in sharp decline. The effect of hatchery strays on wild Chinook salmon production in systems such as the Green/Duwamish River was identified in NMFS's review as a key concern leading to the listing of Chinook salmon (BRT 2003).

Adult Migration and Spawning

Adult Chinook salmon enter the Duwamish River from approximately mid-June through October. After entering the river, many early migrating Chinook salmon hold in the lower river areas (Duwamish to Kent area) until approximately mid-September, depending on temperature and flow (Ruggerone et al. 2004). Holding occurs in low velocity areas of the river, which are upstream of the action area. Water temperature, which is influenced by air temperature and long water residence time (related to flow), may reach stressful levels (72-77ºF or 22-25ºC) during this holding period (Kerwin and Nelson 2000). Initial movement of most fish on to the spawning grounds typically coincides with a freshet (autumn rain storms). Mainstem spawning in the Green River occurs between RM 24 and RM 61.

Juvenile Migration and Habitat Use

Juvenile Chinook salmon typically begin emerging from gravels in January. Seaward migration timing of subyearling Chinook salmon from the spawning reaches of Puget Sound watersheds tends to be bimodal. Some Chinook salmon fry begin moving downstream soon after emergence (typically the majority), whereas others remain upriver to rear in areas closer to the spawning grounds (Nelson et al. 2004). During 2000, approximately 68% of the juvenile Chinook salmon sampled at RM 34.5 migrated during January 1 to April 15 ('fry migrants'), whereas 32% migrated during April 16 to July 13 ('fingerling migrants'). Peak migration of fry typically occurs in early March, followed by few fish migrating during late March through April, and then fingerlings migrating May through early July. Size of 'fry migrants' was approximately 1.4 to 1.8 inches (35-45) mm, whereas size of the later migrating 'fingerling migrants' increased over time from 1.5 to 3.7 inches (46 mm to 93 mm).

Brackish marine water typically extends up to RM 6.5, although extreme high tides may carry saltwater further upriver. Chinook salmon fry begin entering marine areas of the Duwamish in January, typically following a significant rain event. In 2005, salmon fry were readily captured in nearshore areas of the lower Duwamish, but none were captured in mid-channel areas using a 700-foot (213-m) long purse seine (SAIC et al. 2005).

Data collected in recent years indicate juvenile Chinook salmon (and other salmonids) aggregate in the transition zone area where freshwater first mixes with marine waters (Warner and Fritz 1995, Nelson et al. 2004). An intensive study in 2005 indicated the area of relatively high densities of Chinook salmon extended from RM 4.7 to RM 6.5 (Ruggerone et al. 2006). Relatively low densities were observed in downstream areas, such as Kellogg Island. Downstream of the transition zone, juvenile Chinook salmon typically reared in off-channel habitats for only 1 tide cycle (Ruggerone and Jeanes 2004). These data support the hypothesis that juvenile Chinook salmon acclimate and rear in the transition zone, then migrate relatively rapidly through the lower Duwamish.

Juvenile Chinook salmon may be present in marine areas of the Duwamish during all months of the year, as some juvenile salmon re-enter the waterway from Puget Sound during summer through winter. During 2002, residence time of juvenile natural Chinook salmon in marine areas of the Duwamish declined steadily from approximately 28 ± 7 days in late May to 20 ± 7 days in early June to 15 ± 3 days in late June, then increased from 16 ± 4 days in early July to 23 days in late July/mid-August to 58 ± 13 days in early September (Ruggerone and Volk 2004). These data indicate the tendency for late migrating Chinook salmon to spend relatively little time in the estuary, followed by re-entry of Chinook salmon into the lower Duwamish from Puget Sound. Analyses of coded-wire-tagged Chinook salmon indicated non-local Chinook salmon did not extend upstream of Kellogg Island (Nelson et al. 2004).

Juvenile Diet and Growth

Analyses of Chinook salmon stomach contents indicate juveniles captured in mainstem areas of the Duwamish estuary frequently consumed atypical prey compared with those in less disturbed estuaries, whereas those captured in off-channel restoration areas consumed more typical prey, including terrestrial insects (Ruggerone et al. 2004). Additional data collected in 2005 support these observations (Ruggerone et al. 2006).

Growth rates of juvenile Chinook salmon, based on change in mean size each week, suggest growth of Green/Duwamish Chinook salmon is typical of other Chinook salmon populations where data have been collected. However, there was some evidence in 2003 that the release of 3 million hatchery Chinook salmon may have temporarily reduced their growth (Nelson et al. 2004). Examination of daily otolith growth patterns indicated growth in the marine areas of the Duwamish was positively correlated with the last 10 days of growth in freshwater (Ruggerone and Volk 2004). This finding provides evidence that conditions in freshwater can have a lingering effect upon salmon after entering the estuary.

5.1.3.3 North Seattle/Puget Sound, Elliott Bay, and South Seattle/Puget Sound

The North Seattle/Puget Sound, Elliott Bay, and South Seattle/Puget Sound action areas are combined because they border Puget Sound. In Puget Sound, nearshore marine waters are important for juvenile salmon rearing, growth and migration (Brennan et al. 2004, Mavros and Brennan 2001, Williams et al. 2001, Nelson et al. 2004). Nearshore areas also provide spawning habitat for forage fishes, which are important prey for older salmon. The nearshore environment in these action areas is used by various Puget Sound Chinook salmon stocks including the Snohomish River, Cedar River/Lake Washington, Green/Duwamish River, and Puyallup River stocks. Critical habitat has been designated for the nearshore extending along the entire City of Seattle Puget Sound nearshore from extreme high water to a depth of 98.4 feet (30 m) relative to MLLW.

Current Range

No adult Chinook salmon have been documented during spawning surveys initiated by Seattle Public Utilities in 1999 in Piper's and Fauntleroy creeks, which flow directly into Puget Sound (McMillan 2006). Six young-of-the-year Chinook salmon juveniles were found in Lower Piper's Creek during a stream-typing survey in July 1999 (Washington Trout 2000).

Collections with beach seines suggest that juvenile Chinook salmon are oriented to shallow water habitat located close to shore. They are most abundant in intertidal flats and shallow subtidal channels near estuarine and tidal marshes and eelgrass meadows (Toft et al. 2004, Williams et al. 2001).

Migration

Studies on Chinook salmon use of Puget Sound have found that juveniles begin entering into estuaries and the nearshore in late January and early February (Williams et al. 2001). Peak migration into Puget Sound occurs in June and July (KCDNR 2001, Toft et al. 2003, Nelson et al. 2004). Juvenile Chinook salmon are found along the nearshore through October. Current evidence suggests that Chinook salmon may use the nearshore year-round. Mavros and Brennan (2001) sampled from the beginning of June through mid-August and captured Chinook salmon throughout the sampling period. Toft et al. (2004) sampled from mid-May through the first of August and captured Chinook salmon throughout. Beamish et al. (1998) sampled offshore water and captured Chinook salmon into September. Brennan et al. (2004) used beach seines to sample the nearshore of King County, and they caught Chinook salmon in October of 2001 and 2002, but densities were low.

King County sampled juvenile Chinook salmon in a variety of nearshore habitats ranging from Vashon Island to Picnic Point during May to October, 2001 and 2002. About 88% of 58 Chinook salmon originating from Soos Creek Hatchery migrated south after entering Puget Sound; few individuals were captured in nearshore waters of WRIA 8 (Brennan and Higgins 2004). In the Elliott Bay area, most juvenile Chinook salmon captured after June were from Puget Sound watersheds other than the Duwamish (Ruggerone et al. 2004). Nelson et al. (2004) reported that catch rates of juvenile Chinook salmon in Elliott Bay were considerably smaller than catch rates in the Duwamish estuary (RM 0 to RM 7), reflecting rapid dispersal along marine habitats.

Diet, Growth, and Survival

Juvenile Chinook salmon are opportunistic foragers in Puget Sound, feeding on epibenthic and pelagic invertebrates, insects (possibly from drift out of streams, marine riparian vegetation, or recent feeding in freshwater), and small fishes. Ruggerone et al. (2004) noted that many Chinook salmon captured off the Snohomish estuary had consumed insects, which may imply that fish recently left the river, availability of marine prey was somewhat low, or that marine riparian vegetation supplied insects to the nearshore environment. Based on recent work by Brennan and Higgins (2004), Chinook salmon under 6 inches (150 mm) ate a highly varied diet along the shores of King County and Seattle, while Chinook salmon larger than 6 inches (150 mm) ate mostly juvenile fish. Chinook salmon under 6 inches (150 mm) consumed high amounts of polychaetes early in their marine residence and high levels of insects later in the summer. The polychaetes found in the diet were composed mostly of 1 species, which was typically associated with shallow vegetated habitats (i.e., kelp and eelgrass). Anecdotal evidence and studies in other regions indicate that marine riparian areas are important areas for insect prey production.

The importance of Puget Sound to juvenile Chinook salmon was highlighted in a recent study that examined the release of 53 million coded-wire tagged Chinook salmon in the Puget Sound region. This study found that that growth and survival of Puget Sound Chinook salmon declined and age-at maturation was delayed when juvenile Chinook salmon entered Puget Sound during even-numbered years along with numerous juvenile pink salmon (produced by the dominant odd-year return of adult pink salmon) (Ruggerone and Goetz 2004). Survival of even-year Chinook salmon migrants was 62% less than that of odd-year migrants during 1984 to 1997. Analyses indicated that the growth and survival impacts occurred within Puget Sound and Georgia Strait and that survival was influenced by the 1982/83 El Nino and subsequent climate events that influenced prey production in marine waters. These findings suggest that the capacity of Puget Sound to support Chinook salmon (i.e., food availability) may be reduced in some years, but few data are available that examine food availability and/or growth of salmon in Puget Sound over a series of years. The trophic interactions that influenced this significant effect are poorly understood.

5.2 Coastal-Puget Sound Bull Trout

5.2.1 Listing and Critical Habitat Designation

On November 1, 1999, the USFWS (USDI 1999a) listed 5 DPSs of bull trout within the coterminous United States as threatened:

1. Coastal-Puget Sound DPS
2. Columbia River DPS
3. Jarbridge River DPS
4. St. Mary-Belly River DPS
5. Klamath River DPS.

On September 26, 2005, critical habitat was designated for the Coastal-Puget Sound DPS of bull trout (*Salvelinus confluentus*) (70 FR 56212) (see Figure 3). On October 18, 2010, the USFWS revised the 2005 critical habitat designation (75 FR 63898) based on extensive review of the previous critical habitat process. The lateral extent of the critical habitat boundaries for bull trout is the width of the stream channel as defined by the OHW. In areas where the OHW has not been defined, the width of the channel is defined by bankfull elevation. In lakes and reservoirs, critical habitat is delineated by the perimeter of the waterbody as mapped on standard 1:24,000 scale maps. The inshore extent of critical habitat for marine nearshore areas is the MHHW, including tidally influenced freshwater heads of estuaries. The offshore extent of critical habitat for marine nearshore areas is based on the extent of the photic zone (depth to which sunlight can penetrate to permit photosynthesis), which is about 33 feet (10 m). See Figure 3 for a map of this area.

The areas designated as critical habitat for the Coastal-Puget Sound DPS of bull trout are designed to incorporate what is essential for their conservation. An area need not include all 9 of the PCEs listed below to qualify for designation as critical habitat. All lands identified as essential and designated as critical habitat contain 1 or more of the primary constituent elements for bull trout.

The following are the 9 PCEs for the **Coastal-Puget Sound DPS for bull trout critical habitat**:

- **Coastal-Puget Sound Bull Trout Critical Habitat PCE #1**: Springs, seeps, groundwater sources, and subsurface water connectivity (hyporheic flows) to contribute to water quality and quantity and provide thermal refugia.
- **Coastal-Puget Sound Bull Trout Critical Habitat PCE #2**: Migration habitats with minimal physical, biological, or water quality impediments between spawning, rearing, overwintering, and freshwater and marine foraging habitats, including but not limited to permanent, partial, intermittent or seasonal barriers.
- **Coastal-Puget Sound Bull Trout Critical Habitat PCE #3**: An abundant food base, including terrestrial organisms of riparian origin, aquatic macroinvertebrates, and forage fish.
- **Coastal-Puget Sound Bull Trout Critical Habitat PCE #4**: Complex river, stream, lake, reservoir, and marine shoreline aquatic environments, and processes that establish and maintain these aquatic environments, with features such as large wood, side channels, pools, undercut banks and unembedded substrates, to provide a variety of depths, gradients, velocities, and structures.
- **Coastal-Puget Sound Bull Trout Critical Habitat PCE #5**: Water temperatures ranging from 2 to 15 ºC (36 to 59 ºF), with adequate thermal refugia available for temperatures that exceed the upper end of this range. Specific temperatures within this range will depend on bull trout life-history stage and form; geography; elevation; diurnal and seasonal variation; shading, such as that provided by riparian habitat; streamflow; and local groundwater influence.
- **Coastal-Puget Sound Bull Trout Critical Habitat PCE #6**: In spawning and rearing areas, substrate of sufficient amount, size, and composition to ensure success of egg and embryo overwinter survival, fry emergence, and young-of-the-year and juvenile survival. A minimal amount of fine sediment, generally ranging in size from silt to coarse sand, embedded in larger substrates, is characteristic of these conditions. The size and amounts of fine sediment suitable to bull trout will likely vary from system to system.
- **Coastal-Puget Sound Bull Trout Critical Habitat PCE #7**: A natural hydrograph, including peak, high, low, and base flows within historic and season ranges or, if flows are controlled, minimal flow departure from a natural hydrograph.
- **Coastal-Puget Sound Bull Trout Critical Habitat PCE #8**: Sufficient water quality and quantity such that normal reproduction, growth and survival are not inhibited.
- **Coastal-Puget Sound Bull Trout Critical Habitat PCE #9**: Sufficiently low levels of occurrence of nonnative predatory (e.g., lake trout, walleye, northern pike, smallmouth bass); interbreeding (e.g., brook trout); or competing (e.g., brown trout) species that, if present, are adequately temporally and spatially isolated from bull trout.

Critical habitat units are patterned after recovery units identified in the Draft Recovery Plan (USFWS 2004) for the Coastal-Puget Sound DPS. The designated critical habitat within the action areas are within the Puget Sound critical habitat unit (Unit 28). To be included as critical habitat for bull trout, a critical habitat unit had to be occupied by the species and contain sufficient PCEs to provide 1 or more of the following functions:

- Spawning, rearing, foraging, or overwintering habitat to support existing bull trout local populations
- Movement corridors necessary for maintaining migratory life-history forms
- Suitable occupied habitat that is essential for recovering the species.

The Puget Sound critical habitat unit includes both marine and freshwater habitats. It is bordered by the Cascade Crest to the East, Puget Sound to the West, the Lower Columbia and Olympic Peninsula Recovery Units to the South, and the United States-Canada border to the North. The Draft Recovery Plan (USFWS 2004) identifies the need to maintain the 57 local populations and 5 potential local populations. Freshwater and marine foraging, migration, and overwintering habitats within the Puget Sound critical habitat unit are essential for the recovery of bull trout distribution, abundance, and productivity. These habitats are especially important for the amphidromous life-history form in which bull trout migrate to and from marine and freshwater areas.

5.2.2 Species Information

5.2.2.1 Life History

Bull trout are a member of the char family and closely resemble another member of the char family, Dolly Varden (*S. malma*). Genetics indicate, however, that bull trout are more closely related to an Asian char (*S. leucomaenis*) than to Dolly Varden (Pleyte et al. 1992). Bull trout are sympatric (originate and occupy the area) with Dolly Varden over part of their range, most notably in British Columbia and the Coastal-Puget Sound region of Washington.

Within the Coastal-Puget Sound DPS, current bull trout distribution is similar to the historic distribution, but population abundance has significantly decreased in portions of this range (USDI 1999a). Bull trout populations exhibit 4 distinct life-history types: resident, fluvial, adfluvial, and anadromous. Resident, fluvial, and adfluvial forms exist throughout the range of the bull trout (Rieman and McIntyre 1993) and spend their entire life in freshwater. The only known anadromous form within the coterminous United States occurs in the Coastal-Puget Sound region (Volk 2000, Kraemer 1994, Mongillo 1993). Highly migratory populations have been eliminated from many of the largest, most productive river systems across their range. Many ‘resident’ bull trout presently exist as isolated remnant populations in the headwaters of rivers that once supported larger, more fecund migratory forms. These isolated remnant populations—which lack connectivity to migratory populations—have a low likelihood of persistence (Rieman and Allendorf 2001, Rieman and McIntyre 1993).

Most growth and maturation occurs in estuarine and marine waters for anadromous bull trout, in lakes or reservoirs for adfluvial bull trout, and in large river systems for fluvial bull trout. Resident bull trout populations are generally found in small headwater streams where the fish spend their entire lives. These diverse life-history types are important to the stability and viability of bull trout populations (Rieman and McIntyre 1993).

For all life-history types, juveniles rear in tributary streams for 1 to 3 years before migrating downstream into a larger river, lake, or estuary and/or nearshore marine area to mature (Rieman and McIntyre 1993). In some lake systems, juveniles may migrate directly to lakes (Riehle et al. 1997). Juvenile and adult bull trout frequently inhabit side channels, stream margins and pools with suitable cover (Sexauer and James 1993) and areas with cold hyporheic zones or groundwater upwellings (Baxter and Hauer 2000).

Bull trout become sexually mature between 4 and 9 years of age and may spawn in consecutive or alternate years (Pratt 1992, Shepard et al. 1984). Size of sexually maturity varies with life-history type. Resident life-history forms typically mature at a length of about 7.9 to 9.8 inches (20.6- 24.9 cm). Fluvial bull trout mature at an average length of 13.8 inches (35 cm) and anadromous bull trout at 16.7 inches (16.7 cm) (Kraemer 2003). Spawning typically occurs from August through December in cold, low-gradient 1st- to 5th-order tributary streams, over loosely compacted gravel and cobble having groundwater inflow (Shepard et al. 1984, Brown 1992, Rieman and McIntyre 1996, Swanberg 1997, MBTSG 1998, Baxter and Hauer 2000). Spawning sites frequently occur near cover (Brown 1992). Migratory bull trout may begin their spawning migrations as early as April and have been known to migrate upstream as far as 155 miles (250 km) to spawning grounds (Fraley and Shepard 1989). Hatching occurs in winter or early spring, and alevins may stay in the gravel for up to 3 weeks before emerging from the gravel. The total time from egg deposition to fry emergence from the gravel may exceed 220 days. Post-spawning mortality, longevity, and repeat-spawning frequency are not well known (Rieman and McIntyre 1996), but lifespans may exceed 10 to 13 years (McPhail and Murray 1979, Pratt 1992, Rieman and McIntyre 1993).

Bull trout are apex predators and require a large prey base and home range. Adult and subadult migratory bull trout are primarily piscivorous, feeding on various trout and salmon species, whitefish (*Prosopium* spp.), yellow perch (*Perca flavescens*), and sculpin (*Cottus* spp.). Subadult and adult migratory bull trout move throughout and between basins in search of prey. Anadromous bull trout in the Coastal-Puget Sound DPS also feed on ocean fish, such as surf smelt (*Hypomesus pretiosus*) and sandlance (*Ammodytes hexapterus*). Resident and juvenile bull trout prey on terrestrial and aquatic insects, macrozooplankton, amphipods, mysids, crayfish, and small fish (Wyman 1975, Boag 1987, Donald and Alger 1993, Goetz 1989, Rieman and Lukens 1979 in Rieman and McIntyre 1993). A recent study in the Cedar River Watershed of western Washington found bull trout diets also consist of aquatic insects, crayfish, and salamanders (Connor et al. 1997).

5.2.2.2 Factors for Decline

The following factors have contributed to the decline of bull trout populations identified in the listing rule (Bond 1992, Thomas 1992, Donald and Alger 1993, Rieman and McIntyre 1993, WDFW 1997):

- Restriction of migratory routes by dams and other unnatural barriers
- Forest management, grazing, and agricultural practices
- Road construction
- Mining
- Introduction of nonnative species
- Residential development resulting in adverse habitat modification, overharvest, and poaching.

In May, 2004, the USFWS issued a Draft Recovery Plan for the Coastal-Puget Sound DPS (USFWS 2004). The Puget Sound Draft Recovery Plan identifies Lake Washington, the Ship Canal, Lake Union, and the lower Duwamish River as foraging, migration and overwintering habitat. Foraging, migration, and overwintering habitat is defined as relatively large streams and mainstem rivers, including lakes or reservoirs, estuaries, and nearshore environments, where subadult and adult migratory bull trout forage, migrate, mature, or overwinter (USFWS 2004). This habitat is typically downstream from spawning and rearing habitat and contains all the physical elements to meet critical overwintering, spawning migration, and subadult and adult rearing needs. Although use of foraging, migration and overwintering habitat by bull trout may be seasonal or very brief (as in some migratory corridors), it is a critical habitat component.

The Coastal-Puget Sound DPS is significant to the species as a whole because it contains the only anadromous forms of bull trout in the coterminous United States. Consequently, this DPS supports bull trout in a unique ecological setting. Also unique to this population segment is the overlap in distribution with Dolly Varden.

On October 18, 2010, the USFWS revised its September 26, 2005, critical habitat designation for bull trout in the conterminous United States (75 FR 63898). The final rule designated habitat in 32 critical habitat units which have an appropriate quantity and spatial arrangement of physical or biological features present that supports bull trout metapopulations, life processes, and overall species conservation. For the Puget Sound critical habitat unit, the designated critical habitat totals about 1,144 miles (1,840 km) of streams, 40,182 acres (16,261 ha) of lakes, and 443 miles (684 km) of marine shoreline in Washington. Within the action areas, critical habitat includes Lake Washington, the Ship Canal, Lake Union, the Duwamish Waterway, Duwamish River, and the estuarine and marine waters of Puget Sound (see Figure 3).

5.2.2.3 Habitat Requirements

Bull trout have more specific habitat requirements than other salmonids (Rieman and McIntyre 1993). Growth, survival, and long-term persistence depend on the following habitat characteristics:

- Cold water
- Complex instream habitat
- Stable substrate with a low percentage of fine sediments
- High channel stability
- Stream/population connectivity.

Stream temperature and substrate type, in particular, are critical factors for the sustained long-term persistence of bull trout. Spawning is often associated with the coldest, cleanest, and most complex stream reaches within basins. However, bull trout exhibit a patchy distribution even in pristine habitats (Rieman and McIntyre 1995). They should not be expected to occupy all available habitats at the same time (Rieman et al. 1997).

While bull trout clearly prefer cold waters and nearly pristine habitat, it cannot be assumed that they do not occur in streams where habitat is degraded. Given the depressed status of some subpopulations, it is likely that individuals in degraded rivers are using less than optimal habitat because that may be all that is available. In basins with high productivity, such as the Skagit River basin, bull trout may be using marginal areas when optimal habitat becomes fully occupied (Kraemer 2003). Bull trout have been documented using habitats that may be atypical or characterized as likely to be unsuitable (USFWS 2000).

Temperature

For long-term persistence, bull trout populations need a stream temperature regime that ensures sufficient amounts of cold water are present at the locations and during the times needed to complete their lifecycle. Temperature is most frequently recognized as the factor limiting bull trout distribution (Rieman and McIntyre 1993, Dunham and Chandler 2001). Probability of occurrence for juvenile bull trout in Washington is relatively high (7%) when maximum daily temperatures did not exceed about 52° to 54° F (11-12° C) (Dunham et al. 2001). Water temperature also seems to be an important factor in determining early survival, with cold water temperatures resulting in higher egg survival and faster growth rates for fry and juveniles (Pratt 1992). Optimum incubation temperatures range from 36° to 43° F (2-6° C). At 46° to 50° F (8-10° C), survival ranged from 0 to 20% (McPhail and Murray 1979). Tributary stream temperature requirements for rearing juvenile bull trout are also quite low, ranging from 43° to 50° F (6-10° C) (McPhail and Murray 1979, Goetz 1989, Pratt 1992, Buchanan and Gregory 1997).

Increases in stream temperatures can cause direct mortality, increased susceptibility to disease or other sublethal effects and displacement by avoidance (Bonneau and Scarnecchia 1996, McCullough et al. 2001). Temperature increases also increase competition with species more tolerant of warm stream temperatures (MBTSG 1998, Rieman and McIntyre 1993). Brook trout (*S. fontinalis*), which can hybridize with bull trout, may be more competitive than bull trout and displace them, especially in degraded drainages containing fine sediment and higher water temperatures (Clancy 1993, Leary et al. 1993). Recent laboratory studies suggest bull trout are at a particular competitive disadvantage in competition with brook trout at temperatures greater than 54° F (12° C) (McMahon et al. 2001).

Although bull trout require a narrow range of cold water temperatures to rear, migrate, and reproduce, they are known to occur in larger, warmer river systems that may cool seasonally, and that provide important migratory corridors and forage bases. For migratory corridors, bull trout typically prefer water temperatures ranging between 50° to 54° F (10-12° C) (Buchanan and Gregory 1997, McPhail and Murray 1979). When bull trout migrate through stream segments with higher water temperatures, they tend to seek areas offering thermal refuge such as confluences with cold tributaries (Swanberg 1997), deep pools, or locations with surface and groundwater exchanges in alluvial hyporheic zones (Frissell 1999). Water temperatures above 59º F (15° C) are believed to limit bull trout distribution, which partially explains their generally patchy distribution within a watershed (Fraley and Shepard 1989, Rieman and McIntyre 1995).

Substrate

Bull trout show a strong affinity for stream bottoms and a preference for deep pools in cold water streams (Goetz 1989, Pratt 1992). Stream bottom and substrate composition are highly important for juvenile rearing and spawning site selection (McPhail and Murray 1979, Graham et al. 1981, Rieman and McIntyre 1993). Fine sediments can influence incubation survival and emergence success (Weaver and White 1985, Pratt 1992) but might also limit access to substrate interstices that are important cover during rearing and overwintering (Goetz 1994, Jakober 1995). Rearing densities of juvenile bull trout have been shown to be lower when there are higher percentages of fine sediment in the substrate (Shepard et al. 1984). Due to this close connection to substrate, bed load movements and channel instability can negatively influence the survival of young bull trout.

Cover and Stream Complexity

Bull trout of all age classes are closely associated with cover, especially during the day (Fraley and Shepard 1989, Baxter and McPhail 1997). Cover may be in the form of overhanging banks, deep pools, turbulence, large wood, or debris jams. Young bull trout use interstitial spaces in the substrate for cover and are closely associated with the stream bed. This association appears to be more important for bull trout than for other salmonids (Pratt 1992, Rieman and McIntyre 1993).

Bull trout distribution and abundance is positively correlated with pools and complex forms of cover, such as large or complex woody debris and undercut banks, but may also include coarse substrates (cobble and boulder) (Rieman and McIntyre 1993, Jakober 1995, MBTSG 1998). Studies of Dolly Varden showed that population density declined with the loss of woody debris after clearcutting or the removal of logging debris from streams (Bryant 1983, Dolloff 1986, Elliott 1986, Murphy et al. 1986).

Large pools consisting of a wide range of water depths, velocities, substrates, and cover are characteristic of high-quality aquatic habitat and an important component of channel complexity. Reduction of wood in stream channels, either from present or past activities, generally reduces pool frequency, quality, and channel complexity (Bisson et al. 1987, House and Boehne 1987, Spence et al. 1996). Large wood in streams enhances the quality of habitat for salmonids and contributes to channel stability (Bisson et al. 1987). It creates pools and undercut banks, deflects streamflow, retains sediment, stabilizes the stream channel, increases hydraulic complexity, and improves feeding opportunities (Murphy 1995). By forming pools and retaining sediment, large wood also helps maintain water levels in small streams during periods of low streamflow (Lisle 1986).

Channel and Hydrologic Stability

Due to the bull trout's close association with the substrate, bed load movements and channel instability can reduce the survival of young bull trout. Maintaining bull trout habitat requires stream channel and flow stability (Rieman and McIntyre 1993). Bull trout are exceptionally sensitive to activities that directly or indirectly affect stream channel integrity. Juvenile and adult bull trout frequently inhabit areas of reduced water velocity, such as side channels, stream margins, and pools that are easily eliminated or degraded by management activities (Rieman and McIntyre 1993). Channel dewatering caused by low flows and bed aggradation (raising grade or level by deposition) has blocked access for spawning fish resulting in year-class failures (Weaver 1992). Timber harvest and the associated roads may cause landslides that affect many miles of stream through aggradation of the streambed.

Patterns of streamflow and frequency of extreme flow events that influence substrates may be important factors in population dynamics (Rieman and McIntyre 1993). With lengthy overwinter incubation and a close tie to the substrate, embryos and juveniles may be particularly vulnerable to flooding and channel scour associated with the rain-on-snow events common in parts of the range (Rieman and McIntyre 1993). Surface/groundwater interaction zones—which bull trout typically select for redd construction—are increasingly recognized as having high dissolved oxygen, constant cold water temperatures, and increased macro-invertebrate production.

5.2.2.4 Migration

The persistence of migratory bull trout populations requires maintaining migration corridors. Stream habitat alterations that either restrict or eliminate bull trout migration corridors include the following:

- Degradation of water quality (especially increasing temperatures and increased amounts of fine sediments)
- Alteration of natural streamflow patterns
- Impassable barriers (e.g., dams and culverts)
- Structural modification of stream habitat (e.g., channeling or removing cover).

In the Coastal-Puget Sound DPS, migratory corridors may link seasonal marine and freshwater habitats, as well as linking lake, river, and tributary complexes necessary for bull trout life-history requirements.

The importance of maintaining the migratory life-history form of bull trout, as well as migratory runs of other salmonids that may provide a forage base for bull trout, is repeatedly emphasized in the scientific literature (Rieman and McIntyre 1993, MBTSG 1998, Dunham and Rieman 1999, Nelson et al. 2002). Isolation and habitat fragmentation resulting from migratory barriers have negatively affected bull trout by the following:

1. Reducing geographical distribution (Rieman and McIntyre 1993, MBTSG 1998)
2. Increasing the probability of losing individual local populations (Rieman and McIntyre 1993, Dunham and Rieman 1999, MBTSG 1998, Nelson et al. 2002)
3. Increasing the probability of hybridization with introduced brook trout (Rieman and McIntyre 1993)
4. Reducing the potential for movements in response to developmental, foraging, and seasonal habitat requirements (Rieman and McIntyre 1993, MBTSG 1998).
5. Reducing reproductive capability by eliminating the larger, more fecund migratory form from many subpopulations (Rieman and McIntyre 1993, MBTSG 1998).

Therefore, restoring connectivity and restoring the frequency of occurrence of the migratory form will be an important factor in the recovery of bull trout.

Unfortunately, migratory bull trout have been restricted or eliminated in parts of their range due to stream habitat alterations, including seasonal or permanent obstructions, detrimental changes in water quality, increased temperatures, and the alteration of natural streamflow patterns. Dam and reservoir construction and operations have altered major portions of bull trout habitat in the Skokomish, Elwha, Skagit, Nooksack, and Puyallup river core areas. Dams without fish passage create barriers to fluvial and adfluvial bull trout that isolate populations. The operations of dams and reservoirs alter the natural hydrograph, thereby affecting forage, water temperature, and water quality (USDI 1997).

5.2.2.5 Marine Habitat Use

Estuaries and shoreline areas comprise what is known as the ‘nearshore’ marine habitat. The nearshore environment provides habitat critical to both bull trout and salmon. This habitat provides food production and foraging areas, refuge (from predation, seasonal high flows, winter storms), and migratory corridors.

Bull trout first migrate to tidal areas between ages 1 and 3. These juvenile fish may rear in the tidally influenced delta within intertidal marsh, distributary channels, or they may pass through into nearshore marine areas. Although no studies describe the salinity tolerance of bull trout, both subadult and adult bull trout can survive a wide range of salinities, varying from fresh to brackish to marine waters and can move between these areas with little or no delay for acclimation.

Additional information provided by bull trout acoustic radio telemetry and habitat study projects indicates that bull trout in marine waters are more active at night than during the day, may prefer deeper nearshore habitat rather than shallow nearshore habitat, and can be found at depths as great as 197 to 256 feet (60-75 m). Bull trout from different freshwater populations may overlap in their use of marine and estuarine waters. Although bull trout are likely to be found in nearshore marine waters year-round, the period of greatest use is March through July (Goetz and Jeanes 2004). In the Skagit Bay, although bull trout may be found year-round, there appears to be a bi-modal distribution where significant numbers of bull trout are present from April through July and October through December (Beamer and Henderson 2004).

Anadromous bull trout forage and mature in the nearshore marine habitats on the Washington coast, Strait of Juan de Fuca, and in Puget Sound. In Puget Sound, the distribution of bull trout in nearshore waters likely correlates to the nearshore distribution of baitfish (WDFW 1999). It also appears that certain life-history stages may use different marine prey species. For example, the younger bull trout (age 1-3) that move to marine waters appear to select smaller prey items, such as shrimp. By age 4, the diet of anadromous bull trout has shifted largely to fish. Bull trout from Puget Sound prey on surf smelt, Pacific herring (*Clupea harengus pallasi*), Pacific sand lance, pink salmon smolts (*O. gorbuscha*), chum salmon smolts (*O. keta*), and a number of invertebrates (Kraemer 1994).

5.2.3 Species Occurrence in Action Areas

5.2.3.1 Lake Washington Ship Canal, North Lake Washington, South Lake Washington

The Lake Washington Ship Canal, North Lake Washington, and South Lake Washington action areas are combined because they comprise the western portion of the Lake Washington basin. The Lake Washington foraging, migration and overwintering habitat consists of the lower Cedar River below Cedar Falls, the Sammamish River, Lakes Washington, Sammamish and Union, the Ship Canal and all accessible tributaries. Designated critical habitat includes Lake Washington and the Ship Canal. No streams are designated as critical habitat in these action areas.

Current Range

Population status information and extent of use of this area are currently unknown. Adult and subadult size individuals have been observed infrequently in the lower Cedar River (below Cedar Falls), Carey Creek (a tributary to upper Issaquah Creek), Lake Washington, and at the Locks. No spawning activity or juvenile rearing has been observed and no distinct spawning populations are known to exist in Lake Washington outside of the upper Cedar River above Lake Chester Morse (not accessible to bull trout within Lake Washington).

The potential for spawning in the Lake Washington basin is believed to be very low because most accessible habitat is low elevation, below 500 feet (152 m), and thus not expected to have proper thermal regime to sustain successful spawning. There are, however, some coldwater springs and tributaries that may come close to suitable spawning temperatures and that may provide thermal refuge for rearing or foraging during warm summer periods.

Migration

Aside from spawning, Lake Washington drainage has potential benefits and challenges to adult and subadult bull trout. Two large lakes with high forage fish provide significant foraging habitat. Subadult and adult bull trout have been occasionally observed in Lake Washington (Shepard and Dykeman 1977, KCDNR 2000, H. Berge, KCDNRP, pers. comm. 2003). Surface water temperatures in Lake Washington and the Ship Canal are too warm for bull trout during late spring through early fall and probably limit residence time of bull trout that may enter the system through the Locks. Observations of bull trout in the Locks suggest migration is occurring from other watersheds.

Bull trout have been caught in Shilshole Bay and the Locks during late spring and early summer in both 2000 and 2001. In 2000, up to 8 adult and subadult fish (mean size 14.5 inches [36.8 cm]) were caught in Shilshole Bay below the Locks, between May and July. These fish were found preying upon juvenile salmon (40% of diet) and marine forage fish (60% of diet) (Footen 2000, 2003). In 2001, 5 adult bull trout were captured in areas within the Locks and immediately below the Locks. One bull trout was captured within the large locks in June, and in May, one adult was captured while migrating upstream through the fish ladder in the adult steelhead trap at the head of the ladder. Three adult bull trout were also captured below the tailrace during the peak of juvenile salmon migration on June 18, 2001 (F. Goetz, Corps, pers. comm. 2003).

5.2.3.2 Lower Green/Duwamish

The Lower Green/Duwamish action area is considered foraging, migration and overwintering habitat. This foraging, migration and overwintering habitat may be used by several bull trout core populations such as those from the Puyallup and Snohomish rivers. The Duwamish River, including the East and West waterways, is designated critical habitat for the Coastal-Puget Sound DPS.

Current Range

Historically, bull trout were reported to use the Duwamish River and lower Green River in ‘vast’ numbers (Suckley and Cooper 1860). In contrast, bull trout are observed infrequently in this system today. Before permanent redirection of the Stuck River (lower White River) into the Puyallup River system in 1906 (Williams et al. 1975), the lower Green River system provided habitat for populations spawning in the White River. Another factor that may have diminished the Green-Duwamish River system’s value for bull trout is the loss of the Black River due to construction of the Ship Canal in the mid-1910s. The Black River historically connected the Lake Washington basin and Cedar River to the Green-Duwamish River system. Creation of the Ship Canal and Locks lowered Lake Washington 9 feet (2.7 m) and completely redirected flows of the Cedar River and Lake Washington tributaries to the canal (Warner 1996). These diversions left the Green-Duwamish River system with only about one-third of its original watershed (Weitkamp and Ruggerone 2000), which fragmented potential habitats and may have lowered the quality of habitats to support bull trout populations.

Recently, bull trout have been reported in the lower Green River as far upstream as the mouth of Newaukum Creek at about RM 41 and are occasionally reported in the lower Duwamish River (KCDNR 2000, KCDNRP 2002, Goetz et al. 2004). It is presumed that bull trout use the Green River up to City of Tacoma’s Headworks Diversion Dam at RM 61, a barrier to upstream migration since 1912 (KCDNR 2000). Bull trout recently observed in the lower Green River basin likely originated from other watersheds (70 FR 56212). Reports of historic use of tributaries in the lower Green River are rare (KCDNR 2000). Given their size and potential as foraging areas, tributaries such as Newaukum and Soos Creeks may occasionally be used by bull trout. Tributaries within the action area, such as Longfellow Creek, are not likely to be used by bull trout.

The number of bull trout that enter the Duwamish River is small. In April 1978, Dennis Moore, Hatchery Manager for the Muckleshoot Tribe, talked with 3 anglers near North Wind Weir, RM 7 of the Duwamish and identified 4 fish as adult char (Brunner 1999a). In 2000, 8 subadult bull trout were captured in the Duwamish River at the head of the navigation channel at the Turning Basin restoration site at river mile (RM) 5.3. These fish averaged 11 inches (27.9 cm) in length and were captured in August and September. A single char was caught at this same site in September of 2002 (J. Shannon, Taylor Associates, pers. comm. 2002). In May 2003, a 23-inch (58.4 cm) adult char was captured and released at Kellogg Island (J. Shannon, Taylor Associates, pers. comm. 2003). However, no bull trout were captured during weekly beach seining of up to 13 sites per week (RM 1 to RM 8.5) during December 2004 to July 2005 (G. Ruggerone, NRC, pers. comm. 2006).

5.2.3.3 North Seattle/Puget Sound, Elliott Bay, and South Seattle/Puget Sound

The North Seattle/Puget Sound, Elliott Bay, and South Seattle/Puget Sound action areas have been combined because they border Puget Sound. In this action area, critical habitat extends along the entire City of Seattle Puget Sound nearshore (see Figure 3) from extreme high water to 33 feet (10 m) depth relative to the MLLW. Critical habitat includes tidally influenced freshwater areas at the head of estuaries.

Current Range

Anadromous adult and subadult bull trout may use all marine waters of the action area for foraging and overwintering. The extent is poorly understood however. Kraemer (1994) speculated that the distribution of bull trout in marine waters may be closely timed with the distribution of forage fish and coincidental with their spawning beaches. Goetz et al. (2004) documented that bull trout were most abundant in Puget Sound waters during spring and late summer and relatively few were captured during winter months. The current distribution of bull trout within Puget Sound marine waters is not completely known. But it has been documented from the Canadian border to the Nisqually River Delta (Fresh et al. 1979, Kraemer 1994, McPhail and Baxter 1996, WDFW 1998, Pacific International Engineering 1999, Ballinger 2000, KCDNRP 2002). Bull trout appear to be more abundant along eastern shores compared with western shores of Puget Sound (70 FR 56212).

Puget Sound bull trout prey on surf smelt, Pacific herring, Pacific sand lance, and other small schooling fish (Kraemer 1994, Goetz et al. 2004). These prey species are present in all of the marine areas within the action area. Although foraging bull trout may tend to seasonally concentrate in forage fish spawning areas (nearshore habitats), they can be found throughout accessible estuarine and nearshore habitats.

The extent of past and current bull trout use of smaller independent creek drainages that discharge directly into Puget Sound is not well known. No observations have been made of bull trout use in small streams entering Puget Sound within the action areas. Even if it is determined that many of the small stream systems in Puget Sound are not commonly occupied by bull trout, these streams may contribute to the forage base of bull trout in adjacent nearshore marine waters.

Relatively few bull trout have been observed or captured within nearshore areas of the action area. Most migratory bull trout leave freshwater and enter Puget Sound during late winter and spring, then return to freshwater during late spring and early summer (Goetz et al. 2004). Approximately 16 char have been captured in the Golden Gardens area from 1929 to 2002. Eight adult and subadult bull trout were caught in Shilshole Bay in 2000 (Footen 2000, 2003). Tagging indicated that some bull trout captured near the Locks rapidly migrated to other watersheds. A total of 34 bull trout have been captured in Shilshole Bay since 1949. In Elliott Bay, 1 adult bull trout was captured in a Muckleshoot Tribal net near Pier 91 (Brunner 1999b), and 1 bull trout was observed feeding along the new habitat bench created at the Olympic Sculpture Park in June (Toft et al. 2010; J. Toft, UW, pers comm. 2010).

5.3 Southern Resident Killer Whale

5.3.1 Listing and Critical Habitat Designation

On November 15, 2005, NMFS listed the Southern Resident killer whales (*Orcinus orca*) as endangered under the ESA. This new listing under ESA requires federal agencies to make sure their actions do not jeopardize the continued existence of the whales. Southern Resident killer whales are already protected, as are all marine mammals, by a 1972 law, the Marine Mammal Protection Act, under which the whales were officially listed as a depleted stock in May 2003. The final recovery plan, published in January 2008, reviews and assesses the potential factors affecting the Southern Resident killer whales and lays out a recovery program to address each of the threats.

On November 29, 2006, NMFS designated critical habitat for the Southern Resident killer whale. Critical habitat boundaries for Southern Resident killer whales include 3 areas, 1 of which lies within the Seattle action areas. This area, defined as Area 2, includes all of Puget Sound south of Deception Pass Bridge, the entrance to Admiralty Inlet, and the Hood Canal Bridge. Hood Canal is not included as critical habitat. The extent of critical habitat includes all water greater than 20 feet (6.1m) relative to extreme high water.

The PCEs for **Southern Resident killer whale's critical habitat** include:

- **Southern Resident Killer Whale Critical Habitat PCE #1**: Water quality to support growth and development
- **Southern Resident Killer Whale Critical Habitat PCE #2**: Prey species of sufficient quantity, quality, and availability to support individual growth, reproduction, and development, as well as overall population growth
- **Southern Resident Killer Whale Critical Habitat PCE #3**: Passage conditions to allow for migration, resting, and foraging.

5.3.2 Species Information

5.3.2.1 Life History

The Southern Resident killer whale population consists of 3 pods, identified as J, K, and L pods, that reside for part of the year in the inland waterways of the Strait of Georgia, Strait of Juan de Fuca, and Puget Sound, especially during the spring, summer, and fall

(Krahn et al. 2002). The population experienced a 20% decline in the 1990s, raising concerns about its future. The population peaked at 97 animals in the 1990s and then declined to 71 in 2001. There were increases in the overall population from 2002-2007, however the population declined in 2008 with 85 Southern Resident killer whales counted. As of July 1, 2010, the population of Southern Resident killer whales totals 87 individuals (Center for Whale Research 2011). Individual pod sizes include 28 members in J Pod, 19 in K pod, and 40 in L Pod.

Many members of the group were captured during the 1970s for commercial display aquariums. The group continued to be put at risk from vessel traffic, toxic chemicals, and limits on availability of food, especially salmon. It has only a few sexually mature males. Because the population historically has been small, it is susceptible to catastrophic risks, such as disease or oil spills.

Killer whales are strikingly pigmented cetaceans. Killer whales are black dorsally and white ventrally, with a conspicuous white oval patch located slightly above and behind the eye. Sexual dimorphism occurs in body size, flipper size, and height of the dorsal fin. Males are larger and develop larger pectoral flippers, dorsal fins, tail flukes, and girths than females (Clark and Odell 1999).

Killer whales have been classified into 3 forms, or ecotypes, termed residents, transients, and offshore whales. Significant genetic differences occur among the 3 forms (Stevens et al. 1989, Hoelzel and Dover 1991, Hoelzel et al. 1998, Barrett-Lennard 2000, Barrett-Lennard and Ellis 2001, Hoelzel et al. 2002). The 3 forms vary in morphology, ecology, and behavior.

5.3.2.2 Factors for Decline

The exact cause of the recent decline of the Southern Resident population is unknown and could be a combination of 2 or more factors. Factors resulting in decreased numbers to the Southern Resident population are the following:

1. Reduced quantity and quality of prey
2. Persistent pollutants that could cause immune or reproductive system dysfunction
3. Oil spills
4. Noise and disturbances from vessel traffic.

Adequate prey populations are important to healthy killer whale populations and reductions in prey availability may force whales to spend more time foraging and might lead to reduced reproductive and higher mortality rates. Many stocks of salmon have declined due to overfishing and degradation of freshwater and estuarine habitat through urbanization, dam building and forestry, agricultural, and mining practices (NRC 1996, Gregory and Bisson 1997, Lichatowich 1999, Pess et al. 2003). Due to lack of information on the diet of killer whales throughout the year and the importance of the various salmon runs, it is unknown whether current fish stocks are a limiting factor for the Southern Resident population.

Killer whales are experiencing ever-increasing amounts of indirect harassment through expanding contact with human-made sources of marine noise and vessel traffic. Underwater noise pollution originates from several sources, including general shipping and boating traffic, industrial activities such as dredging, drilling, marine construction, and seismic testing of the sea bottom, and military and other vessel use of sonar (Richardson et al. 1995, Gordon and Moscrop 1996, NRC 2003). Many of these activities are prevalent in coastal areas, coinciding with the preferred habitat of most killer whale populations. Killer whales rely on their highly developed acoustic sensory system for navigating, locating prey, and communicating with other individuals. Excessive levels of human-generated noise and the physical presence of vessels have the potential to mask echolocation and other signals used by killer whales thereby causing increased physiological changes and lowered immune function, and can disrupt movements and normal behavioral patterns.

Another primary factor in the decline of killer whales is exposure to elevated levels of toxic chemical contaminants, especially organochlorine compounds such as polychlorinated biphenyls (PCBs) and DDT. Bioaccumulation through trophic (nutritional) transfer allows relatively high concentrations of these compounds to build up in killer whales because they are a top-level marine predator. The effects of chronic exposure to moderate-to-high contaminant levels have not yet been determined in killer whales. There is no evidence that high organochlorine concentrations cause direct mortality in killer whales (O'Shea and Aguilar 2001). However, physiological responses in marine mammals have been linked to organochlorine exposure, including impaired reproduction (Béland et al. 1993), immunotoxicity (Lahvis et al. 1995, Ross et al. 1995, Ross 2002), hormonal dysfunction (Subramanian et al. 1987), disruption of enzyme function and vitamin A physiology (Marsili et al. 1998, Simms et al. 2000), and skeletal deformities (Bergman et al. 1992).

5.3.2.3 Habitat Requirements

Southern Resident killer whales use different summer and winter habitats. All 3 Southern Resident pods regularly occur in the water of the Georgia Basin (the Strait of Georgia, Haro Strait, and the Strait of Juan de Fuca) during late spring, summer, and early fall (Heimlich-Boran 1988). The range of Southern Residents throughout the rest of the year is not well known. During the early fall, movements of Southern Residents, particularly J pod, expand to include Puget Sound (Krahn et al. 2002).

Killer whales are the world's most widely distributed marine mammal (Leatherwood and Dahlheim 1978, Heyning and Dahlheim 1988). Although observed in tropical waters and the open sea, they are most abundant in coastal habitats and high latitudes. In the eastern Pacific Ocean, killer whales occur year-round in southeastern Alaska (Scheffer 1967) and the intercoastal waterways of British Columbia and Washington State (Balcomb and Goebel 1976, Bigg et al. 1987, Osborne et al. 1988). They have been observed near the Aleutian Islands (Murie 1959, Waite et al. 2001) and along the coasts of Washington, Oregon, and California (Norris and Prescott 1961, Fiscus and Niggol 1965, Rice 1968, Gilmore 1976, Black et al. 1997, NMFS 2004).

In Washington, killer whales occur in all marine waters. From late spring to fall, most whales can be found in the inland waters around the San Juan Islands (Heimlich-Boran 1988, Felleman et al. 1991, Olson 1998, Ford et al. 2000). Movements during the winter and early spring are poorly known, but many animals shift their activity to outer coastal areas or depart the state.

Killer whales are highly social animals that occur primarily in groups or pods of up to 40 to 50 animals (Dahlheim and Heyning 1999, Baird 2000). Mean pod size varies among populations, but often ranges from 2 to 15 animals (Kasuya 1971, Condy et al. 1978, Mikhalev et al. 1981, Braham and Dahlheim 1982, Dahlheim et al. 1982, Baird and Dill 1996). Differences in spatial distribution, abundance, and behavior of food resources probably account for much of the variation in group size among killer whale populations.

Diet

As top-level predators, killer whales eat a variety of marine organisms ranging from fish to squid to other marine mammal species. Some populations have specialized diets throughout the year and use specific foraging strategies that reflect the behavior of their prey. Such dietary specialization has probably evolved in regions with abundant prey resources year-round (Ford 2002). Cooperative hunting, food sharing, and innovative learning are other notable foraging traits in killer whales (Smith et al. 1981, Lopez and Lopez 1985, Felleman et al. 1991, Hoelzel 1991, Jefferson et al. 1991, Hoelzel 1993, Simala and Ugarte 1993, Baird and Dill 1995, Guinet et al. 2000, Pitman et al. 2003).

Fish are the major dietary component of resident killer whales (Ford et al. 1998, 2000; Saulitis et al. 2000). Observations indicate that salmon are clearly preferred as prey, especially in spring, summer, and fall. Resident whales spend about 50% to 67% of their time foraging (Heimlich-Boran 1988, Ford 1989, Morton 1990, Felleman et al. 1991). During early autumn, Southern Resident pods, especially J pod, expand their routine movements into Puget Sound to likely take advantage of chum and Chinook salmon runs (Osborne 1999). Little is known about the winter and early spring foraging of resident killer whales. NMFS (2011a) has informed affected constituents about the importance of Chinook salmon to the diet of SR killer whales and the potentially serious implications of the salmon fisheries and other activities affecting Chinook salmon on the survival and recovery of SR killer whales.

While in inland waters during warmer months, all of the pods concentrate their activity in Haro Strait, Boundary Passage, the southern Gulf Islands, the eastern end of the Strait of Juan de Fuca, and several localities in the southern Georgia Strait (Heimlich-Boarn 1988, Felleman et al. 1991, Olson 1998, Ford et al. 2000). Less time is spent elsewhere in other sections of the Georgia Straight, San Juan Islands, Admiralty Inlet and Puget Sound.

Killer whales frequent a variety of marine habitats with adequate prey resources and do not appear to be constrained by water depth, temperature, or salinity (Baird 2000). Killer whales tolerate a range of water temperatures, occurring from warm tropical seas to polar regions with ice floes and near-freezing waters. They occasionally enter brackish waters and rivers (Scheffer and Slipp 1948).

Mortality

Killer whales are polygamous. Males nearly always mate with females outside of their own pods, thereby reducing the risks of inbreeding (Dahlheim and Heyning 1999, Barrett-Lennard 2000, Barrett-Lennard and Ellis 2001). Most mating is believed to occur from May to October, although mating occurs year-round because young are born in all months (Nishiwaki 1972, Olesiuk et al. 1990b, Matkin et al. 1997). Gestation in captive killer whales averages about 17 months (Asper et al. 1988, Walker et al. 1988, Duffield et al. 1995).

Mortality is extremely high during the first 6 months of life, when 37% to 50% of all calves die (Bain 1990, Olesiuk et al. 1990b). Annual death rates for juveniles decline steadily thereafter. Mortality rates are about 0.5% to 1.7% per year until the age of 44.5 years. Mortality increases dramatically among older females, especially those older than 65 years. After reaching sexual maturity, death rates for males increase throughout life, reaching 7.1% annually among individual older than 30 years. Mortality rates appear highest during the winter and early spring.

At birth, the average life expectancy of resident killer whales is about 29 years for females and 17 years for males (Olesiuk et al. 1990b). However, for animals that survive their first 6 months, mean life expectancy increases to about 50 to 60 years for females and 29 years for males. Sexual maturity occurs around 15 years of age in both sexes. Maximum lifespan is estimated to be 80 to 90 years for females and 50 to 60 years for males (Olesiuk et al. 1990b).

5.3.3 Species Occurrence in Action Areas

5.3.3.1 North Seattle/Puget Sound, Elliott Bay, and South Seattle/Puget Sound

SR killer whales spend considerable time in the Georgia Basin from late spring to early autumn, with concentrated activity in the inland waters of the state of Washington around the San Juan Islands, and then move south into Puget Sound in early autumn. While these are seasonal patterns, Southern Resident killer whales have the potential to occur throughout their range (from Central California north to the Queen Charlotte Islands) at any time of the year.

The Whale Museum manages a long-term database of SR killer whale sightings and geospatial locations in inland waters of Washington. While these data are predominately opportunistic sightings from a variety of sources (public reports, commercial whale watching, Soundwatch, Lime Kiln State Park land-based observations, and independent research reports), SR killer whales are highly visible in inland waters, and widely followed by the interested public and research community. The dataset does not account for level of observation effort by season or location; however, it is the most comprehensive long-term dataset available to evaluate broad scale habitat use by SR killer whales in inland waters. For these reasons, NMFS relies on the number of past sightings to assess the likelihood of SR killer whale presence in a project area when work would occur. A review of this dataset from the years 1990 to 2008 indicates that SR killer whales are observed in Puget Sound along the City of Seattle throughout the year. Within Elliott Bay, SR killer whales have been observed in all months except May, June, and July (NMFS 2011b).

The database may be found at www.nwr.noaa.gov/marine-mammals/mm-occurrence.cfm.

5.4 Humpback Whale

5.4.1 Listing and Critical Habitat Designation

Humpback whales (*Megaptera novaeangliae*) have been protected since 1965, and are currently listed as endangered under the ESA. In the North Pacific, most remaining humpbacks reside in United States territorial waters (i.e. winter and summer grounds).

The humpback whale has a worldwide distribution, with 4 major populations or stocks (NMFS 2009, website http://www.nmfs.noaa.gov/pr/sars/species.htm#largewhales):

1. Western North Atlantic
2. Eastern North Pacific
3. Central North Pacific
4. Gulf of Maine.

5.4.2 Species Information

5.4.2.1 Life History

The humpback whales that can be found within Puget Sound and along the Washington coast belong to the Eastern North Pacific stock (NMFS 2005, Eastern North Pacific Stock Assessment). These whales winter in coastal Central America and Mexico and migrate to the coast of California to southern British Columbia in summer.

Data in population abundance shows a general upward trend in abundance of humpback whales from 1991 through 1998. From 1999 to 2001, a large, but not significant, drop occurred. In 2001, the humpback whale population was estimated to be 1,109 individuals. Current 2005 estimates of the population of the Eastern North Pacific Stock are 1,769 individuals (Forney 2007).

Females are slightly larger than males averaging 48 feet (14.6 m) in length. Males average 44 feet (13.4 m). The maximum recorded size is 59 feet (17.9 m). A full-grown adult weighs about 30 tons (27.2 metric ton) with an expected lifespan of 40 to 50 years. Humpback whales are characterized by extremely long flippers that are about 0.33% of total body length, a dark back with white pigmentation on the flippers, sides, and ventral surface, a series of wart-like bumps called tubercles on the upper and lower jaw, and long, complex vocalizations. Prey includes herring, sand lance, capelin, mackerel, walleye pollock, haddock, and krill (Bryant et al. 1981, Krieger and Wing 1984). Adult humpback whales consume up to 3,000 pounds (1,360 kg) per day, although likely only feed during the 6 to 9 months of the year they are on their feeding grounds. Humpbacks fast and live off their fat layer for the winter period while on their breeding grounds.

Mating and birth of young probably takes place at the wintering grounds. Females produce their first calf between the ages of 6 and 8, and typically have 1 calf every 2 to 4 years. Humpbacks are born during the winter and are 10 to 13 feet long (3-3.9 m) and weigh about 2,200 lbs (997 kg).

5.4.2.2 Factors for Decline

Humpbacks were killed extensively from the late 1800s through the first part of the 20th century. Worldwide the population of humpbacks is about 10,000. This is 8% of the historical population size, although this species is now protected and recovering. The greatest threats to humpbacks today are entanglements in fishing gear, ship strikes, and coastal habitat pollution. The pre-1905 population of humpback whales in the North Pacific was about 15,000. By 1966, whaling had reduced this population to about 1,200 individuals. More than 6,000 humpback whales currently exist in the North Pacific (Carretta et al. 2001).

5.4.3 Species Occurrence in Action Areas

5.4.3.1 North Seattle/Puget Sound, Elliott Bay, and South Seattle/Puget Sound

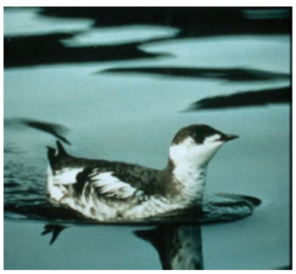
The occurrence of humpbacks in Puget Sound within the action areas is considered very unlikely or infrequent. Sightings of humpback whales are uncommon along the coast of Washington, although the National Marine Mammal Laboratory has documented humpbacks in Washington state waters in every month except February, March, and April. Humpbacks probably use Washington waters as a migration corridor. Historically, populations of humpbacks were much higher along the Washington coast. In the early 1900s, humpbacks were landed at the Bay City, Washington whaling station from April to October with most taken between June and August. Whaling stations off Vancouver

Island also historically caught 500 to 1000 whales with most being humpback (NMFS 1991).

In the past, humpback whales have been intermittently sighted in Puget Sound. A total of 8 sightings have occurred in Puget Sound. Individual humpbacks were observed in May 1976, June 1978, June 1986, 2 juveniles in June and July 1988, Sept 2004, 1 individual observed in May and June 2004 (Falcone et al. 2005), and an injured whale in July 2006. These sightings include Puget Sound and the Georgia Basin (Falcone et al. 2005). The number of humpback sightings reported to the Orca Network has increased from 3 in 2001 to 30 in 2004. Today, 1 to 2 humpback whales typically come into Puget Sound each year (J. Calambokidis, Cascadia Research, pers. comm.). Humpbacks observed in Puget Sound do not remain for long periods and are generally considered to be stragglers.

5.5 Marbled Murrelet

5.5.1 Listing and Critical Habitat Designation



The marbled murrelet (*Brachyramphus marmoratus*) was federally listed as a threatened species in Washington, Oregon, and northern California effective September 28, 1992 (USDI 1992). Extensive harvest of late-successional and old-growth forests—the habitat preferred for nesting by murrelets—was the primary reason for the listing. Other factors include high predation rates and mortality in gillnets and oil spills.

The final rule designating critical habitat for the murrelet (61 FR 26256, USDI 1996) became effective on June 24, 1996. Thirty-two units totaling 3,887,800 acres (1,573,343 ha) were designated on federal, state, county, city, and private lands in Washington, Oregon, and California. Of the 3,887,800 acres designated as critical habitat rangewide, about 1,631,100 acres (600,085 ha) were designated in Washington state (1,800 acres in Congressionally Withdrawn Lands, 1,200,200 acres in late successional reserves, 426,800 acres in state lands, and 2,500 acres in private lands) (USDI 1996). Most of these units (78%) occur on federal lands; 21% on state lands, 1.2% on private lands; 0.2% on county lands; and 0.003% on City lands. Critical habitat designations on state lands were suspended upon completion of the WDNR Habitat Conservation Plan (USFWS 1997). Therefore, about 99.8% of the critical habitat in Washington State is on federal lands.

The USFWS did not include the marine environment in the critical habitat designation because other regulations protect the quality of marine foraging habitat and prey species. While clean water and food in the marine environment were identified as essential to the conservation of the murrelet, the primary threats to these elements are pollution, toxic spills, and degradation of prey habitat. Commercial and recreational fishing did not appear to be a threat to habitat at this time. Several laws specifically regulate activities that could result in pollution, toxic spills, or degradation of prey habitat in the marine environment and attempt to reduce the risk of such events. These include the Clean Water Act; the Marine Protection, Research, and Sanctuaries Act; and the Coastal Zone Management Act. Therefore, the USFWS determined that these areas do not require special management consideration or protection through designation as critical habitat.

5.5.2 Species Information

5.5.2.1 Life History

The marbled murrelet is a small seabird that feeds primarily on fish and invertebrates in nearshore marine waters. Most marbled murrelets are found within or adjacent to the marine environment, although these birds have been detected on rivers and inland lakes (Carter and Sealy 1986). Marbled murrelets spend most of their lives on the ocean and come inland to nest, although they visit some inland stands during all months of the year. Marbled murrelets have been recorded up to 50 miles (80 km) inland in Washington (Hamer and Cummins 1991). Marbled murrelets are not evenly distributed from the coast to the maximum inland distances, with higher detections being recorded closer to the coast. Hamer and Cummins (1991) found that over 90% of all observations were within 36 miles (60 km) of the coast in the northern Washington Cascades.

Marbled murrelets do not reach sexual maturity until their second year. Like other alcids, adult marbled murrelets produce 1 egg per nest. Alcids typically have a variable (not all adults may nest every year) reproductive rate. Marbled murrelets exhibit this same trend.

Adult marbled murrelets lay 1 egg on the limb of an old-growth conifer tree. Nesting occurs over an extended period from mid-April to late September (Carter and Sealy 1987). Incubation lasts about 30 days and fledging takes another 28 days (Simons 1980, Hirsch et al. 1981). Both sexes incubate the egg in alternating 24-hour shifts (Simons 1980, Singer et al. 1991). Flights by adults are made from ocean feeding areas to inland nest sites most often at dusk and dawn (Hamer and Cummins 1991). The adults feed the chick at least once per day, carrying 1 fish at a time (Carter and Sealy 1987, Hamer and Cummins 1991, Singer et al. 1992). The young are altricial and remain in the nest longer than young of most other alcids. Before leaving the nest, the young molt into a distinctive juvenile plumage. Fledglings appear to fly directly from the nest to the sea, rather than exploring the forest environment first (Hamer and Cummins 1991).

Murrelets tend to be more vocal at sea compared to other alcids (Nelson 1997). Individuals of a pair vocalize after surfacing apart from each other (Strachan et al. 1995). Vocalizations among pairs also occur after a disturbance (Strachan et al. 1995). When pairs are separated by boats, most will vocalize and attempt to reunite (Ralph unpub. data, and Miller pers. comm. in Strachan et al.1995). Strachan et al. (1995) believe that foraging plays a major role in pairing and that some sort of cooperative foraging technique may be being employed. This is evidenced by the fact that most pairs of murrelets consistently dive together during foraging and that they often swim towards each other before diving (Carter and Sealy 1990). Pairs of birds resurface together on most dives, and Strachan et al. (1995) suggest that they may keep in visual contact underwater.

Strachan et al. (1995) defines a ‘flock’ as 3 or more birds in close proximity and maintaining that formation when moving. Various observers throughout the range of the murrelet report flocks of highly variable sizes. In the southern portion of the murrelet’s range (California, Oregon, and Washington) flocks rarely contain more than 10 birds. Larger flocks usually occur during the later part of the breeding season and may contain juvenile and subadult birds (Strachan et al. 1995).

Aggregations of foraging murrelets are probably related to concentrations of prey. In Washington, murrelets are not generally found in interspecific feeding flocks (Strachan et al. 1995). Strong and others (in Strachan et al. 1995) observed that murrelets avoid large feeding flocks of other species and presumed that the small size of murrelets may make them vulnerable to kleptoparasitism or predation in mixed species flocks. Strachan et al. (1995) pointed out that if murrelets are foraging cooperatively, then the confusion of a large flock of birds might reduce foraging efficiency.

At-sea courtship begins in early spring, continues through summer, and has also been noted in winter (Speckman 1996 and G. van Vliet pers. comm. in Nelson 1997). A sharp increase in the number of pairs displaying occurs in late July. Courtship involves bill posturing, swimming together, diving synchronously, vocalization, and chasing in flights just above the surface of the water. Copulation occurs both in trees and on the water (Nelson 1997). Observations of courtship occurring in the winter suggest that pair bonds are maintained throughout the year (Speckman 1996, and G. van Vliet pers. comm. in Nelson 1997).

Adult (after-hatch-year) murrelets have 2 primary plumage types: alternate plumage and 'basic' plumage. The alternate plumage is sometimes referred to as breeding plumage and the basic plumage is often referred to as winter plumage. Adult murrelets go through 2 periods of molt. The pre-alternate molt occurs before the breeding season. This is an 'incomplete' molt during which the birds lose their body feathers but retain their ability to fly. A complete pre-basic molt occurs after the breeding season. During this molt, the birds lose all flight feathers relatively synchronously and are flightless for up to 2 months (Nelson 1997).

Timing of molts varies from year to year and from location to location, as well as among individuals. Factors such as prey resources, stress, and reproductive success influence the timing (Nelson 1997). In general, the pre-alternate molt occurs from late February to mid-May, and prebasic molt occurs from mid-July through December (Carter and Stein 1995). However, in Washington, there is some indication that the pre-basic molt occurs from mid-July through the end of August (C. Thompson, WDFW, pers. comm. 2003).

5.5.2.2 Habitat Requirements

Marbled murrelets use older forest stands near the coastline for nesting. These forests are generally characterized by large trees (> 32 inches [80 cm] diameter at breast height), multi-storied stand, and a moderate to high canopy closure. In certain parts of the range, marbled murrelets are also known to use mature forests with an old-growth component. Trees must have large branches or deformities for nest platforms (Binford et al. 1975, Carter and Sealy 1987, Hamer and Cummins 1990, 1991; Singer et al. 1991, 1992). Marbled murrelets tend to nest in the oldest trees in the stand.

It is difficult to locate individual nests for a species that may only show activity near its nest once per day, and may do so under low light conditions. Therefore, occupied sites or suitable habitat become the most important parameters to consider when evaluating status. Strong indicators of occupied habitat are active nests, egg shell fragments or young found on the forest floor; birds seen flying through the forest beneath the canopy; birds seen landing; or birds heard calling from a stationary perch.

Marbled murrelets more commonly occupy old-growth forests compared to mixed-age and young forests in Washington. Stand size is also an important factor for marbled murrelets. They commonly occupy larger stands (> 500 acres [202 ha]). Marbled murrelets are usually absent from stands less than 80 acres (24 ha) in size (Paton and Ralph 1988, Ralph et al. 1990). In Washington, marbled murrelets are found more often when available old-growth, mature forests make up over 30% of the landscape. Similarly, fewer murrelets are found when clearcut or meadow areas make up more than 25% of the landscape (Hamer and Cummins 1990).

Concentrations of marbled murrelets offshore are almost always adjacent to older forests onshore. Nelson (1990) and Ralph et al. (1990) found marbled murrelets were absent offshore where onshore older forests were absent. Large geographic gaps in offshore marbled murrelet numbers occur in areas such as that between central and northern California (a distance of 300 miles [480 km]), and between Tillamook County, Oregon, and the Olympic Peninsula (a distance of 120 miles [190 km]), where nearly all older forest has been removed near the coast.

Although nesting occurs inland, murrelets spend most of their lives in marine waters (USDI 1992). Most surface time is spent loafing, preening, and wing stretching (Strachan et al. 1995). Marine habitat is also used for courtship activity from early spring through summer (Nelson 1997).

During the summer, murrelets primarily use bays, inlets, fjords, and open ocean within 3.1 miles (5 km) of shore and usually occur in widely dispersed concentrations of singles or pairs of birds (Nelson 1997). In Washington, murrelets are generally foraging in shallow waters within 1.2 miles (2 km) of shore (Strachan et al. 1995). Murrelets aggregate where food is clumped, but will otherwise avoid other individuals while feeding (Carter and Sealy 1990). Juveniles are found closer to shore than adults (rarely >0.6 miles [1 km] offshore) (Beissinger1995). During the breeding season, some feeding areas, referred to as 'traditional nurseries' are used consistently on a daily and yearly basis (Carter and Sealy 1990). Kuletz and Piatt (1999) found that in Alaska juvenile marbled murrelets congregated in kelp beds (*Nereocystis* sp.). Kelp beds are often associated with productive waters and may provide protection from avian predators (Kuletz and Piatt 1999). McAllister (unpub. data, in Strachan et al. 1995) found that juveniles were most common within 3,228 feet (100 m) of shorelines, particularly where bull kelp was present, and that the juveniles were less wary and more approachable by boat.

Little is known about the murrelet's marine-habitat preference during spring and fall, but is thought to be similar to that preferred during breeding (Nelson 1997). Few data are available on winter use of marine habitats. There may be a general shift from exposed outer coasts into more protected waters (Nelson 1997).

Diet

Murrelets use their wings for swimming underwater in pursuit of prey and can dive to great depths within nearshore waters. The deepest record of a marbled murrelet was from a bird captured at 89 feet (27 m) in a gill net (Carter and Erickson 1992). They seem to prefer shallow water (<196 feet [60 m] deep), but are known to forage in water up to 1,312 feet (400 m) deep (Nelson 1997). Prey is captured throughout the water column, including near the bottom (Sanger 1987 in Nelson 1997).

Throughout their range, murrelets are opportunistic feeders, using prey of diverse sizes and species. When feeding chicks, adult murrelets are restricted to selecting single fish that range from 0.8 to 2.4 inches (2-6 cm) long. This restriction forces breeding adults to exercise more specific foraging strategies when feeding chicks. As a result, the distribution and abundance of prey suitable for feeding chicks may greatly influence the overall foraging behavior during the nesting season. The availability of abundant forage fish during the nestling period may significantly reduce the energy demand on adults by reducing both foraging time and number of trips inland for feeding nestlings (USDI 1992).

Throughout the breeding season, the primary fish species taken include Pacific sand lance (*Ammodytes hexapterus*), northern anchovy (*Engraulis mordax*), Pacific herring (*Clupea harengus*), capelin (*Mallotus villosus*), surf smelt (*Hypomesus* sp.), and viviparous seaperch (*Cymatogaster aggregata*) (Nelson 1997). In winter and spring the dominant prey are euphasiids (e.g., *Thysanoessa* sp. and *Euphausia* sp.), mysids (e.g., *Acanthomysis* sp., and *Neomysis* sp.), gammarid amphipods, capelin, smelt, and herring (Burkett 1995 in Nelson 1997).

Some foraging occurs at night but murrelets forage most actively in morning and late afternoon (Strachan et al. 1995). Speckman et al. (2000) found murrelet numbers highest in the morning, declined throughout the day, and then sometimes increased slightly in the evening. They also noted that peak numbers occurred on high or falling morning tides, especially in areas with abundant Pacific sand lance.

Predation

Primary threats to murrelets in the marine environment are entanglement in nearshore fisheries nets and marine pollution. Other threats to murrelets in the marine environment include capture by fishing lures (documented in British Columbia and California), and annoyance and/or flushing by boats, commercial machinery, and recreational activities in important feeding areas (USDI 1992). Recently documented fish kills from pile driving have raised concern over the slight-to-severe impacts to murrelets that may occur as the result of some marine construction activities.

Large nearshore net fisheries occur in Washington and California. Mortality of seabirds from nearshore net fisheries can have serious impacts to local seabird populations. Net-caused mortalities of marbled murrelets have been documented in Alaska, Washington and California. Despite efforts to reduce net-caused mortality, it is likely that net mortality has had and still may have substantial impacts on murrelet populations, especially in Puget Sound (USDI 1992).

Mortality and reduced breeding success of seabirds due to marine pollution is well-known. In the 1900s, large oil spills have killed millions of seabirds worldwide. Because marbled murrelets use nearshore waters extensively, they are highly susceptible to the impacts of oil spills. Marine pollution may affect murrelets as well, though the effects have not been fully investigated (USDI 1992).

5.5.3 Species Occurrence in Action Areas

Monitoring of murrelet population size and status is conducted from the effectiveness monitoring program of the Northwest Forest Plan. Annual at-sea population surveys have occurred since 2000. The monitoring survey results indicate a population decline in murrelets throughout their range since 2000 (USFWS 2009). Within Puget Sound (Conservation Zone 1 - which also includes the Straits of Juan de Fuca), there is a significant decline in the population of murrelets. The mean average annual change in the number of murrelets between 2001 and 2008 was a minus 7.9%. Since 2004, data on nest success from radio telemetry and adult:juvenile ratios as an index of breeding success confirms that reproduction in Washington California is too low to sustain populations of murrelets.

No monitoring of murrelets occurs within the action areas. The action areas are included in stratum 3 of the Conservation Zone 1 effectiveness monitoring which includes all of Puget Sound south of the San Juan Islands and south Hood Canal. Five of 47 primary sampling units within stratum 3 are monitored yearly and bird densities for these sites are used throughout the stratum. Densities within stratum 3 between 2004 and 2008 ranged from 0.29 birds/km^2 in 2004 to 2.02 birds/km^2 in 2005 (Falxa et al. 2008). Mean density from 2004 through 2008 is approximately 1.2 birds/km^2.

For determining the density of murrelets for a project and an action area, the USFWS uses the mean density of the stratum for which the project is located. Therefore, the mean density of murrelets within the three action areas of Puget Sound is 1.2 birds/km^2. However, the action areas are highly urbanized, having high barge and ferry traffic, and lack forage fish which makes it unfavorable for murrelets. Forested habitat within the action areas are early-to-late successional forest and therefore not expected to be used by marbled murrelets.

5.6 Puget Sound Steelhead

5.6.1 Listing and Critical Habitat Designation

Puget Sound steelhead (*Oncorhynchus mykiss)* were listed as threatened under the ESA on May 11, 2007 (72FR26722). NMFS determined that naturally spawned winter- and summer-run steelhead populations have had widespread declines in abundance over the last 9 years (since 1996 when NMFS determined that the Puget Sound Steelhead did not warrant listing). The rule protects anadromous *O. mykiss* below longstanding impassable manmade and natural barriers.

Critical habitat for Puget Sound steelhead was proposed on January 14, 2013. The boundaries for Puget Sound steelhead include stream channels within the designated stream reaches, and include a lateral extent as defined by the OHW (33 CFR 319.11).

In areas where OHW has not been defined, the lateral extent of critical habitat will be defined by the bankfull elevation. Bankfull elevation is the level at which water begins to leave the channel and move into the floodplain. The bankfull level is reached at a discharge that generally recurs at an interval of 1 to 2 years on the annual flood series. Critical habitat in lake areas is defined by the perimeter of the waterbody as displayed on standard 1:24,000 scale topographic maps or the elevation of OHW, whichever is greater.

Unlike most other Pacific salmonids, steelhead appear to make only ephemeral use of nearshore marine waters. Steelhead move rapidly through estuaries and nearshore waters to forage on larger prey in offshore marine areas. Due to the rapid migration through the marine nearshore, it was not possible to identify marine nearshore of Puget Sound that is essential to their conservation.

The following are the 6 PCEs for **Puget Sound Steelhead ESU critical habitat**:

- **Puget Sound Steelhead PCE #1**: Freshwater spawning sites with water quantity and quality conditions and substrate supporting spawning, incubation and larval development. There are no freshwater spawning sites within the Seattle action areas.
- **Puget Sound Steelhead PCE #2**: Freshwater rearing sites with water quantity and floodplain connectivity to form and maintain physical habitat conditions and support juvenile growth and mobility; water quality and forage supporting juvenile development; and natural cover such as shade, submerged and overhanging large wood, log jams and beaver dams, aquatic vegetation, large rocks and boulders, side channels and undercut banks.

- **Puget Sound Steelhead PCE #3**: Freshwater migration corridors free of obstruction with water quantity and quality conditions and natural cover such as submerged and overhanging large wood, aquatic vegetation, large rocks and boulders, side channels, and undercut banks supporting juvenile and adult mobility and survival.
- **Puget Sound Steelhead PCE #4**: Estuarine areas free of obstruction and excessive predation with water quality, water quantity, and salinity conditions supporting juvenile and adult physiological transitions between fresh- and saltwater; natural cover such as submerged and overhanging large wood, aquatic vegetation, large rocks and boulders, and side channels; and juvenile and adult forage, including aquatic invertebrates and fish, supporting growth and maturation.
- **Puget Sound Chinook Salmon PCE #5**: Nearshore marine areas free of obstruction with water quality and quantity conditions and forage, including aquatic invertebrates and fish, supporting growth and maturation; and natural cover such as submerged and overhanging large wood, aquatic vegetation, large rocks and boulders, and side channels.
- **Puget Sound Chinook Salmon PCE #6**: Offshore marine areas with water quality conditions and forage, including aquatic invertebrates and fish, supporting growth and maturation.

5.6.2 Species Information

5.6.2.1 Life History

Oncorhynchus mykiss exhibit a complex suite of life-history traits. Even within the confines of Puget Sound and the Strait of Georgia there are considerable life-history variations. Resident *O. mykiss*, commonly called rainbow trout, complete their lifecycle completely in freshwater. Anadromous *O. mykiss*, or steelhead, may reside in freshwater for up to 7 years before migrating to the ocean for 1 to 3 years. Under some circumstances, *O. mykiss* apparently yield offspring of the opposite life-history form (i.e., steelhead offspring become resident rainbow trout, and resident rainbow trout offspring become anadromous steelhead). In contrast with other species of Pacific salmon, *O. mykiss* are iteroparous, capable of repeat spawning.

There are 2 major life-history types—stream-maturing and ocean-maturing—expressed by anadromous *O. mykiss*, related to the degree of sexual development at the time of adult freshwater entry (Smith 1969, Burgner et al. 1992). Stream-maturing steelhead, also called summer-run steelhead, enter freshwater at an early stage of maturation, usually from May to October. These summer-run steelhead migrate to headwater areas and hold for several months prior to spawning in the spring. Ocean-maturing steelhead, also called winter-run steelhead, enter freshwater from November to April at an advanced stage of maturation, spawning from March through June. While there is some temporal overlap in spawn timing between these forms, in basins where both winter- and summer-run steelhead are present, summer-run steelhead spawn farther upstream, usually above a partially impassable barrier (Behnke 1992, Busby et al. 1996). In many cases it appears that the summer migration timing evolved to access areas above a series of falls or cascades that present a velocity barrier to migration during high winter flow months (especially in rain and snow driven basins), but are passable during low summer flows. The winter-run of steelhead is the predominant run in Puget Sound, in part because there are relatively few basins in the Puget Sound ESU with the geomorphological and hydrological characteristics necessary to establish the summer-run life history. The summer-run steelhead's extended freshwater residence prior to spawning results in higher prespawning mortality levels than those of winter-run steelhead. This survival disadvantage may explain why winter-run steelhead predominate where no migrational barriers are present (D. Rawding, WDFW, pers. comm. in BRT 2005) or freshwater migration distances to saltwater are less than 137 miles (200 km).

Steelhead spawn in late winter through spring beginning as early as January and ending in June. Peak spawning usually occurs in April and May. Females dig redds and deposit eggs in the gravel. Eggs hatch after 35 to 50 days depending upon water temperature. Alevins remain in the gravel 2 to 3 weeks until their yolk sac is absorbed and then emerge as fry and begin to actively feed.

Most steelhead juveniles reside in freshwater for 2 years before emigrating to marine habitats, with limited numbers emigrating as 1 or 3-year old smolts. Smoltification and seaward migration occur principally from April to mid-May (WDF et al. 1973). Two-year-old naturally produced smolts are usually 5 to 6 inches (140-160 mm) long (Wydoski and Whitney 2003, Burgner et al. 1992). The inshore migration pattern of steelhead in Puget Sound is not well understood; it is generally thought that steelhead smolts move quickly offshore (Hartt and Dell 1986).

Steelhead oceanic migration patterns are poorly understood. Evidence from tagging and genetic studies indicates that Puget Sound steelhead travel to the central North Pacific Ocean (French et al. 1975, Hartt and Dell 1986, Burgner et al. 1992). Puget Sound steelhead feed in the ocean for 1 to 3 years before returning to their natal stream to spawn. Typically, Puget Sound steelhead spend 2 years in the ocean.

5.6.2.2 Factors for Decline

The following factors have contributed to the decline of Puget Sound steelhead populations identified in the listing rule:

- Reduction or elimination of historically accessible habitat due to water diversions for agriculture, flood control, domestic, and hydropower purposes.
- Degradation, simplification, fragmentation, and losses of habitat from forestry, agriculture, mining, and urbanization.
- Destruction or modification of estuarine areas have resulted in the loss of important rearing and migration habitats.
- Sedimentation and degraded water quality from extensive and intensive land use activities (e.g., timber harvests, road building, livestock grazing, and urbanization).
- Migration barriers and habitat modification (hydrology, temperature, gravel and large woody debris recruitment) from large dams and other human-made barriers.
- Alteration of hydrologic, sedimentation, and stormwater pollution by loss of riparian vegetation and soils from urbanization.
- Loss and reduction of river braiding and sinuosity through land development.
- Inadequacy of existing regulatory mechanisms to reduce risks from habitat degradation from land-use activities and hatchery operations.
- Increased risks to natural populations as a result of food resource competition, increased predation, reduced genetic diversity and reproductive fitness through

interbreeding, and masking of trends in natural populations through the straying of hatchery-origin fish onto spawning grounds and other fish hatchery operations.

5.6.2.3 Habitat Requirements

Steelhead use a variety of habitats throughout the freshwater portion of their life history. Small tributary streams with steep gradient (3-5%) are used for spawning and juvenile rearing (Oregon Department of Fish and Wildlife 1998). Substrate sizes no larger than four inches (10.2 cm) are preferred for spawning (Bjornn and Reiser 1991). As with all salmonid species, water temperatures and intra-gravel flow are also important for spawning and incubation. Water temperatures below 59º F (15º C) are preferred for spawning and incubation (Oregon Department of Fish and Wildlife 1998; Myrick and Cech 2001). Intra-gravel flow provides oxygen and removes metabolic waste. Substrates with low percentages (< 10%) of fines (< 0.12 in. [0.3 cm]) provide optimal gravel conditions for spawning and incubation (Raleigh et al. 1986). Water depths required for spawning vary, but range from a few inches to several feet (Bjornn and Reiser 1991, Healey 1991).

After fry emerge from the gravels, they seek complex habitat of boulders, rootwads, and woody material along the stream margins (Oregon Department of Fish and Wildlife 1998, Paron and Nelson 2001). Juvenile steelhead are year-round residents and water velocity is very important in determining habitat utilization (Placer County 2003). Shallow riffles with higher flows are used in the summer (Barnhart 1986), and all flows are used during the winter (Oregon Department of Fish and Wildlife 1998). Juvenile steelhead feed on invertebrates and, therefore, seek habitats (substrate and flows) that minimize energy expenditure (Placer County 2003).

As juveniles get older and larger they move downstream to rear in larger tributaries and mainstem rivers. Undercut banks, large woody debris, and boulders are all utilized by larger juveniles. Juvenile steelhead may stay in freshwater for up to 3 years before moving into the estuary and migrating out to sea. Smolt transformation requires cooler temperatures (43º-50º F or 6.1º-10º C) than rearing (63º-77º F or 17.2º-25ºC) (Placer County 2003). Steelhead spend little time in estuaries prior to heading out to sea (Oregon Department of Fish and Wildlife 1998, Emmett et al. 1991 in KCDNR 2001).

In estuaries, juvenile steelhead feed on gammarid amphipods, small crustaceans, insects, aquatic worms, fish eggs, and small fish. In marine waters, juvenile and adult steelhead eat fish, crustaceans, squid, herring, and insects (Emmett et al. 1991 in KCDNR 2001).

5.6.3 Species Occurrence in the Action Areas

5.6.3.1 Lake Washington Ship Canal, North Lake Washington, South Lake Washington

The Lake Washington Ship Canal, North Lake Washington, and South Lake Washington action areas are combined because they comprise the western portion of the Lake Washington basin.

Current Range

Within the tributaries of the Ship Canal, North Lake Washington, and South Lake Washington action areas, Puget Sound steelhead is limited to Thornton Creek. There have been 2 confirmed sightings of adult steelhead in Thornton Creek since 2001 (McMillan 2006). Steelhead are also found in Lake Washington and the Ship Canal.

The Washington Department of Fish and Wildlife identifies a single stock of winter steelhead within Lake Washington (WDF et al. 1993; WDFW 2010a). This stock includes spawning populations in tributaries to Lake Washington, Cedar River, Lake Sammamish, and the Sammamish River (WDF et al. 1993). The National Marine Fisheries Service identifies two stocks within Lake Washington; the Cedar River and the North Lake Washington populations (NMFS 2005). Geographical isolation exists between spawning populations in at least 8 tributaries, but the degree of straying/mixing between these populations is unknown. In 1992, the Lake Washington stock status was considered depressed because of the steep decline in numbers (18% annual decline) and the low population growth rate (NMFS 2005). In 2002, the stock status was changed to critical due to chronically low escapements and a short-term severe decline in escapement in 2000 and 2001 (WDFW 2010a). The winter steelhead population has steadily decreased since the mid-1980s (Kerwin 2001). Adult Lake Washington winter steelhead have experienced a high rate of predation by California sea lions (*Zalophus californianus*) below the fish ladder at the Locks (up to 60%) (Kerwin 2001).

The Lake Washington basin winter steelhead escapement estimates for 1986 through 2004 (WDFW 2010a) are shown in Figure 4.

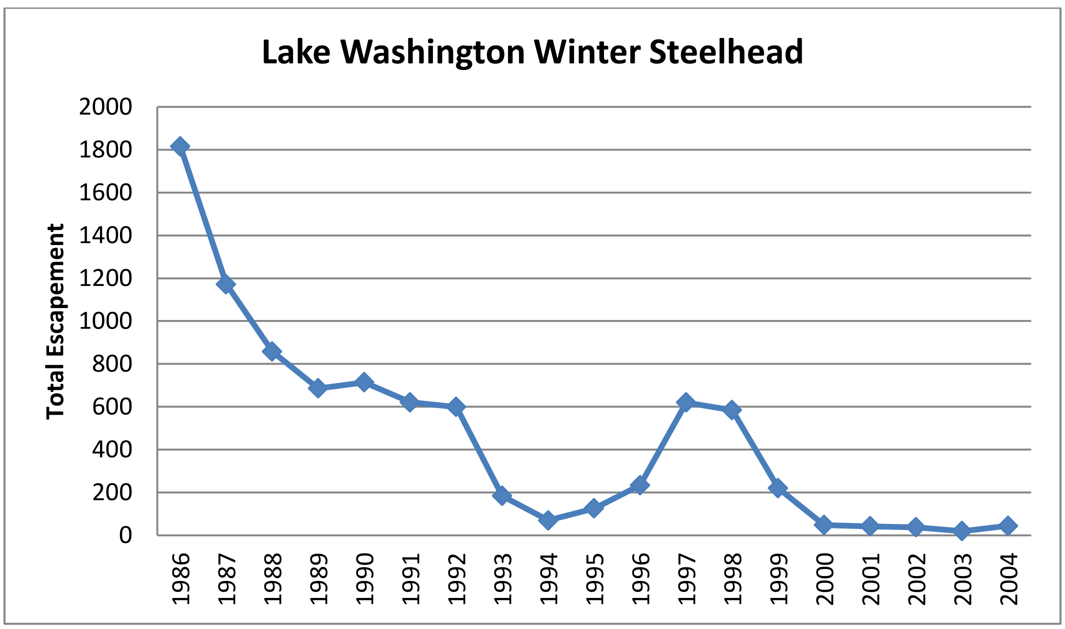


Figure 4

Lake Washington basin winter steelhead escapement estimates for 1986 to 2004.

Adult steelhead begin migrating upstream through the Locks beginning in October (NMFS 2005). Smolts migrating to Puget Sound go through the Locks in mid-June to early July (Kerwin 2001). For Chinook salmon, smolts may remain in the Locks area for days to weeks while steelhead smolts may move through the Locks in hours or days.

Thornton Creek

Only 2 adult steelhead have been documented in Thornton Creek since the City of Seattle began spawning surveys in 2001, including weekly surveys after 2002. The 2 sightings include the following: a 20- to 21-inch (51-53 cm) male carcass in the mainstem downstream of 45th Avenue NE on February 7, 2002, and a 26-inch (66 cm) female carcass in the lower 1,500 ft (457 m) of the North Branch on March 30, 2004 (McMillan 2006). Although possible steelhead redds and live fish were documented in Thornton Creek from 2001 through 2004, it is likely that most of these were large adfluvial cutthroat trout from Lake Washington, which commonly spawn in Thornton Creek in the winter and spring (McMillan 2006). Adult steelhead were observed in Thornton Creek in 1991, 1992, and 1995 (Kerwin 2001). Historically, Thornton Creek probably had steelhead (Trotter 2002). In addition, Thornton Creek received state releases of hatchery-reared rainbow and cutthroat trout on and off from 1937 to 1982, including steelhead from the Seward Park Hatchery in 1937 (WDFW fish stocking records).

Drainages Outside of City Limits

Steelhead are found in a number of Lake Washington and Sammamish River tributaries including Bear Creek, Little Bear Creek, North Creek, Swamp Creek, May Creek, Mercer Slough, and Evans Creek. Abundance of steelhead within these tributaries is unknown (Kerwin 2001, NMFS 2005).

5.6.3.2 Lower Green/Duwamish

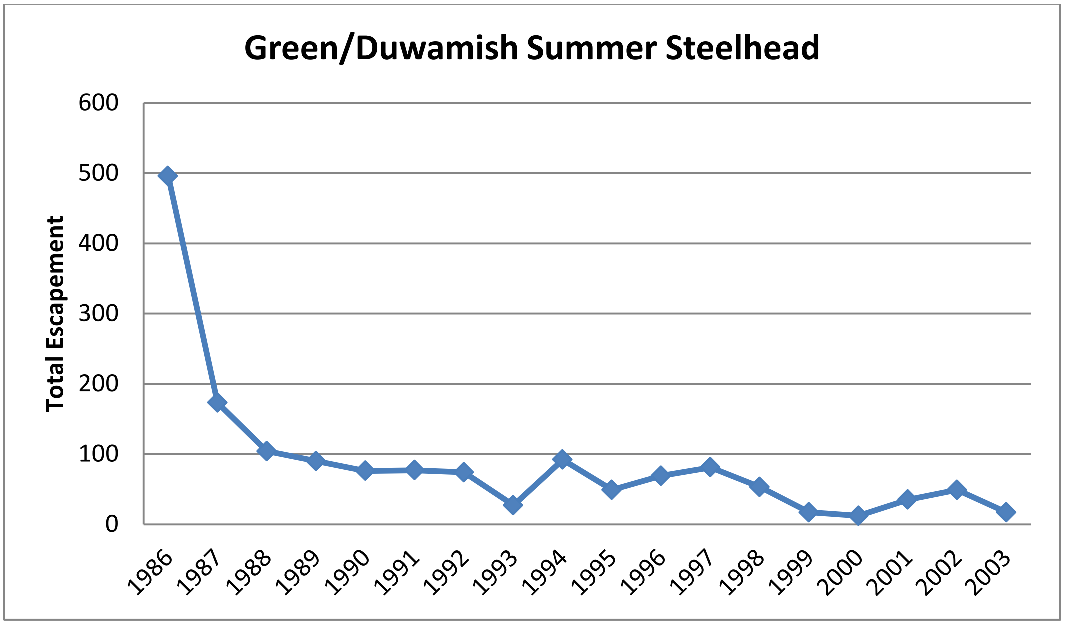
Current Range

Two stocks of Puget Sound steelhead are found within the Green/Duwamish rivers, a summer-run and a winter-run stock. Both populations were considered healthy in 1992 (WDF et al. 1993). In 2002, the status was changed to depressed based on a long-term negative trend and short-term severe decline in 1999 and 2000 in harvest (WDFW 2010a). In 2002, the winter run status stayed the same – healthy. The summer run is a non-native stock sustained by a mixture of artificial and natural production, while the winter run is a native stock, also sustained by a mixture of artificial and natural production. Population trends of Green River wild winter steelhead in the early 1990s began a steady decrease (KCDNR and WSCC 2000).

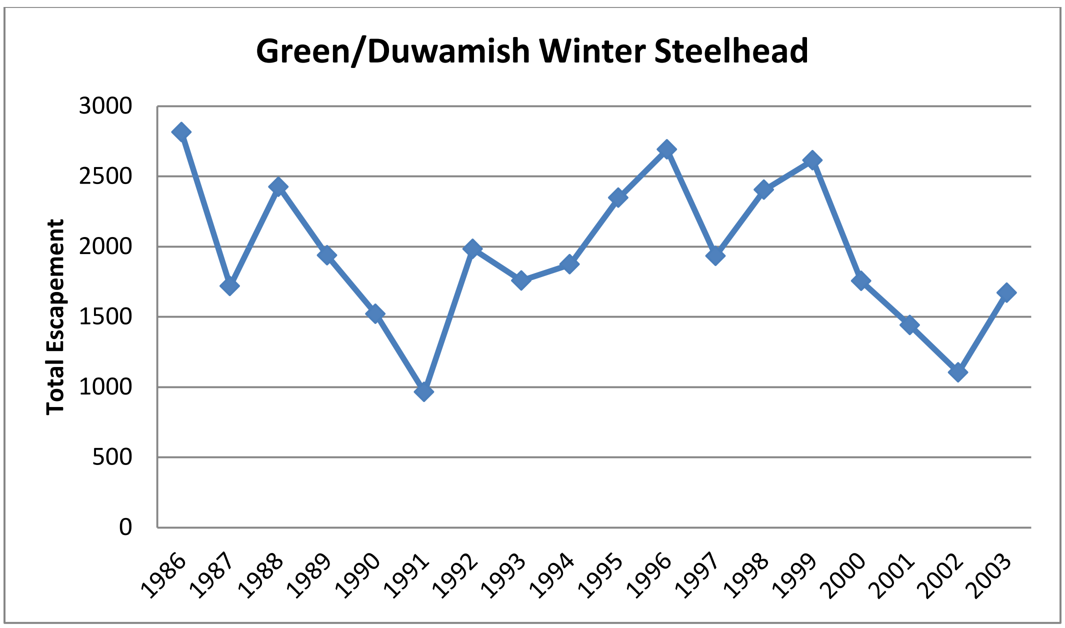
The Green/Duwamish River summer steelhead escapement estimates for 1986 through 2003 (WDFW 2010a) are shown in Figure 5.

Figure 5

Green/Duwamish River Steelhead Escapement Estimates



The Green/Duwamish summer steelhead escapement estimates for 1986 to 2003.



Green/Duwamish River winter steelhead escapement estimates for 1986 to 2003 (WDFW 2010a).

Timing of steelhead migration, spawning/incubation, and rearing varies with the summer- and winter-run stocks. The summer-run stock's upstream migration ranges from April through October, while the winter-run stock ranges from November through May. Spawning for the summer-run stock begins at the end of January and continues through March. The winter-run stock begins spawning in February and ends at the end of June.

Incubation begins at the time of spawning and continues through July for the summer-run and August for the winter-run stock. Because of the steelhead life history, juvenile rearing is found throughout the year. Outmigration of juveniles begins in the middle of March and continues to the middle of July for both stocks (KCDNR 2001).

The run size for the winter-run steelhead stock in the Green/Duwamish River was 12,000 to almost 14,000 in 1977 to 1979 and has declined fromn 3,000 to 4,500 in 1997 and 1998, respectively (KCDNR 2001). Even with the decline in numbers of the Green/Duwamish winter steelhead, WDFW considers the stock to be healthy (KCDNR 2001).

5.6.3.3 North Seattle/Puget Sound, Elliott Bay, and South Seattle/Puget Sound

The North Seattle/Puget Sound, Elliott Bay, and South Seattle/Puget Sound action areas are combined because they border Puget Sound. In Puget Sound, nearshore marine waters are important for juvenile salmon rearing, growth and migration (Mavros and Brennan 2001, Williams et al. 2001, Brennan et al. 2004, Nelson et al. 2004). Nearshore areas also provide spawning habitat for forage fish, which are important prey for steelhead.

Current Range

Observations of steelhead are spotty and confined to nearshore habitats. Steelhead have been observed south of Elliot Point, off Golden Gardens, in Shilshole Bay, at Alki Point, and within Elliott Bay at the mouth of the Duwamish River (KCDNR 2001). In a recent study of the nearshore habitat in WRIAs 8 and 9 (including Vashon and Maury Islands in WRIA 9), 591 beach seine samples were collected in 2001 and 2002 (KCDNR 2001). Almost 34,000 salmonids were caught and of these, only 9 were steelhead (Brennan et al. 2004). These steelhead were captured from May through August with no steelhead caught in April, September, October, or December. Samples were not collected in November, or January through March. Of these 9 steelhead, 3 were captured within the action area; 2 were caught at Lincoln Park in 2001, and 1 was caught at Carkeek Park in 2002.

Tributary Use

Puget Sound steelhead historically had runs in some of the smaller tributaries to Puget Sound, such as Piper's Creek (Kerwin 2001). However, these runs have become extinct. Currently, no steelhead are known to use any of the tributary streams that enter directly into Puget Sound.

5.7 Eulachon

5.7.1 Listing and Critical Habitat Designation

Eulachon (*Thaleichthys pacificus*) were listed as threatened under the ESA on May 17, 2010 (75FR13012). NMFS determined that eulachon, also known as Pacific smelt, candlefish, or Columbia River smelt, is comprised of two or more DPSs that qualify as species under the ESA. NMFS listed the southern DPS of eulachon, consisting of populations spawning in rivers south of the Nass River in British Columbia, Canada, to the Mad River in California. Major core populations for eulachon include the Columbia and Fraser rivers.

On January 5, 2011, NMFS proposed critical habitat for eulachon. Proposed designated critical habitat includes the lower Columbia River, six tributaries to the lower Columbia

River, and the Elwha River on the Olympic Peninsula. The following are the 3 PCEs for **southern DPS of eulachon proposed critical habitat**:

- **Eulachon PCE #1:** Freshwater spawning and incubation sites with water flow, quality and temperature conditions and substrate supporting spawning and incubation.
- **Eulachon PCE #2:** Freshwater and estuarine migration corridors 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.
- **Eulachon PCE #3:** Nearshore and offshore marine foraging habitat with water quality and available prey, supporting juveniles and adult survival.

While the nearshore and offshore marine foraging habitat is essential for eulachon survival and growth to adulthood, NMFS stated they have little information on the distribution of eulachon in the marine waters and where foraging habitat might occur. Therefore, they were unable to identify any specific areas in marine waters that meet the definition of critical habitat under the ESA. NMFS will continue to gather information and will consider revising the designation of critical habitat to include portions of the marine environment necessary for the recovery of eulachon.

5.7.2 Species Information

5.7.2.1 Life History

Eulachon are anadromous fish that spawn in the lower reaches of river systems. Spawning generally occurs in rivers that are glacier-fed or have peak spring hydrographs. Eggs and larvae rapidly move out of the stream into estuaries. Imprinting is believed to be on the estuary rather than the individual streams themselves.

Entry into freshwater and spawning varies through the range of eulachon. In the Columbia River system, eulachon migrate into the river and spawn in December and January. In the Fraser River, migration and spawning occurs in April and May. Spawning occurs when water temperatures are cold. Spawning occurs at temperatures from 32 ^{o}F (0 ^{o}C), or under ice, to 45 ^{o}F (7 ^{o}C).

Most spawning occurs when eulachon are 2 or 3 years of age, with data showing that they only spawn once (Clark et al 2007). Eulachon migrate up river beyond the saltwater to spawn. Spawning occurs at night onto clean sand or small gravel (Cambria Gordon 2006). Females may release up to 25,000 eggs in flowing water and males release milt at the same time. Eggs adhere to the sand and gravel substrate.

Eggs incubate for 3 to 4 weeks depending on water temperature. Upon hatching, larvae are carried downstream to the estuary where they feed on plankton. Eulachon are a schooling fish and have been found near the ocean bottom at depths of 66 to 492 ft (20 to 150 m). When adults reach sexual maturity in late summer and early fall, they leave the schools and migrate back to the rivers to spawn.

Eulachon have numerous predators including fish, sea birds, marine mammals, and terrestrial mammals. Fish predators include white sturgeon, spiny dogfish, sablefish, salmon sharks, arrowtooth flounder, salmon, bull trout, Pacific halibut, and Pacific cod. Sea bird predators include harlequin ducks, pigeon guillemots, common murres mergansers, cormorants, gulls, and eagles. Marine mammal predators include baleen whales, orcas, dolphins, and pinnipeds. Terrestrial mammal predators include brown bears and wolves.

5.7.2.2 Factors for Decline

The primary factors responsible for the decline of the southern DPS of eulachon are the destruction, modification, or curtailment of habitat and inadequacy of existing regulatory mechanisms. Specific risks to eulachon include:

- Changes in ocean conditions due to climate change. Marine, estuarine, and freshwater habitat in the Pacific Northwest have been influenced by climate change over the past 50 to 100 years.
- Dams and water diversion for hydropower generation and flood control that block eulachon migration, alter the natural hydrograph, reduce the magnitude of spring freshets, impede or alter bedload movement, and change the composition of the river substrates important to spawning,
- Water quality degradation due to large-scale impoundments that increase water temperature. Chemical contaminants are present due to urbanization and agriculture.
- Dredging in river mouths alter spawning substrates and can directly kill eggs.
- Commercial harvest poses a risk to eulachon, although current harvest levels are magnitude lower than historic harvest levels. Recreation and tribal harvest still exist but at low intensity.
- Predation primarily from marine mammals, fishes, and birds pose a low level of risk.
- Bycatch of eulachon in commercial fisheries is a moderate risk especially in the shrimp fishery.

5.8.2.3 Habitat Requirements

Eulachon use 3 specific types of habitat: estuary, ocean, and freshwater. Each habitat is specific to certain life history stages. The larval life stage uses the estuarine habitat, as eulachon grow, they move out to the deeper ocean habitat, and adults migrate up into the estuaries and then into the streams to spawn.

Eulachon enter the estuary either during the egg stage or immediately after hatching. Eggs and larvae are swept out of the river by high spring flows. Within the estuaries, larval eulachon use the nearshore vegetation to forage and avoid predation. Prey species include phytoplankton, crustaceans such as copepods, and barnacle and worm larvae. Larval eulachon are distributed throughout the water column in the estuary, but most are found near the bottom or intermediate depths (Wilson et al. 2006).

Ocean distribution has been identified through by-catch of the shrimp fishery. Eulachon schools are found near the ocean bottom at depths of 66 to 492 ft (20 to 150 m) foraging on plankton. The migration of eulachon in the ocean is unknown.

Eulachon spend very little time in freshwater. Adults migrate into the freshwater to spawn. Spawning occurs at night or late afternoon. Spawning occurs at a variety of depths ranging from a few inches (mm) to 25 ft (7.6 m) (Wilson et al. 2006). Spawning substrates include silt, sand, gravel, cobbles and detritus. Sand is the most common substrate. Spawning reaches are typically influence by tides, but are above the saltwater wedge.

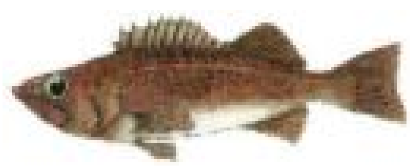
5.7.3 Species Occurrence in Action Areas

5.7.3.1 North Seattle/Puget Sound, Elliott Bay, and South Seattle/Puget Sound

The occurrence of eulachon in Puget Sound within the action areas is considered to be rare or infrequent. Any eulachon in the action areas will be migratory fish originating from river systems outside the action area. Within the greater Puget Sound and Strait of Georgia, eulachon are known to spawn in the Frazier River, but have been identified in the Skagit Bay and in the Puyallup River (BRT 2008). Based on the proposed critical habitat designation, within Puget Sound and the Strait of Georgia, only the Elwha River on the Olympic Peninsula has spawning eulachon and habitat essential to the conservation of the species.

5.8 Bocaccio

5.8.1 Listing and Critical Habitat Designation



Bocaccio (*Sebastes paucispinis*) were listed as endangered under the ESA on April 28, 2010 (75FR22276). NMFS determined that bocaccio is comprised of three DPSs that qualify as species under the ESA; northern coastal, southern coastal, and Georgia Basin DPS. NMFS listed the Georgia Basin DPS.

Critical habitat for bocaccio was designated on November 13, 2014 (79 FR 68041). Both nearshore and deepwater marine waters were identified as critical habitat for bocaccio. Nearshore critical habitat is defined from the extreme high water out to a depth no greater than 30 m (98 ft) relative to mean lower low water. Deepwater critical habitat for occurs from depths greater than 30 m (98 ft).

Juvenile bocaccio settlement habitats located in the nearshore with substrates such as sand, rock and/or cobble compositions that also support kelp are essential for conservation because these features enable forage opportunities and refuge from predators and enable behavioral and physiological changes needed for juveniles to occupy deeper adult habitats. Several attributes of these sites determine the quality of the area and are useful in considering the conservation value of the associated feature and in determining whether the feature may require special management considerations or protection. The following are the two (2) PCEs for bocaccio nearshore critical habitat:

- Quantity, quality, and availability of prey species to support individual growth, survival, reproduction, and feeding opportunities; and

- Water quality and sufficient levels of dissolved oxygen to support growth, survival, reproduction, and feeding opportunities.

Adult bocaccio deepwater benthic habitats and sites deeper than 30 m (98 ft) that possess or are adjacent to areas of complex bathymetry consisting of rock and or highly rugose habitat are essential to conservation because these features support growth, survival, reproduction, and feeding opportunities by providing the structure for rockfish to avoid predation, seek food and persist for decades. Several attributes of these sites determine the quality of the habitat and are useful in considering the conservation value of the associated feature, and whether the feature may require special management considerations or protection. The following are the three (3) PCEs for bocaccio deepwater critical habitat:

- Quantity, quality, and availability of prey species to support individual growth, survival, reproduction, and feeding opportunities;

- Water quality and sufficient levels of dissolved oxygen to support growth, survival, reproduction, and feeding opportunities; ; and

- The type and amount of structure and rugosity that supports feeding opportunities and predator avoidance.

5.8.2 Species Information

5.8.2.1 Life History

Bocaccio are a marine species that were once common on steep walls in Puget Sound. The maximum age of bocaccio is 45 years and they can grow to approximately 3 ft (0.9 m) in length, and 15 pounds in weight. Bocaccio mature at approximately 14 in (35.6 cm) in length. Males begin maturing at age three and females at age four. As a rockfish, bocaccio bear live young. Copulation and fertilization occurs in the fall, generally between August and November. Females produce between 20,000 to over 2 million larvae between January and April. Peak release of larvae is in February.

Upon release from the female, larvae bocaccio are pelagic, staying in the water column in the ocean, for 3.5 to 5.5 months. At this time, the juvenile bocaccio settle to shallow areas. Growth is rapid growing 0.02 to .04 in (0.56 to 0.97 mm) per day.

As juveniles grow, they migrate to deeper waters. The adults tend to stay in the same area throughout their life, moving into shallow areas during the day. Some adult bocaccios are migratory and are constantly moving from location to location.

Larval bocaccio feed on plankton floating in the water. Prey includes larval krill, diatoms and dinoflagellates. Juveniles are opportunistic feeders preying on fish larvae, copepods, and krill. Larger juveniles and adults are primarily piscivores eating other rockfish, hake, sablefish, anchovies, lanternfishes, and squid. Predators to bocaccio include Chinook salmon, terns, and harbor seals.

5.8.2.2 Factors for Decline

The primary factors responsible for the decline of the Georgia Basin DPS of bocaccio are overutilization for commercial and recreational purposes, water quality problems including low dissolved oxygen, and inadequacy of existing regulatory mechanisms. Specific risks to bocaccio include:

- Low dissolved oxygen
- Continued losses as by-catch in recreational and commercial harvest

- The reduction of kelp habitat necessary for juvenile recruitment.

5.9.2.3 Habitat Requirements

Rockfish are the most common bottom and mid-water dwelling fish. Adult rockfish use various coastal benthic habitats such as kelp forests, rock reefs, and rocky outcrops at depths that can exceed 980 ft (299 m). Larvae are found in the surface waters and dispersal of rockfish are influenced by diel, tidal, or vertical migration.

Juveniles and subadults are common in the shallow water associated with rocky reefs, kelp canopies, and artificial structures such as piers. Adults generally move into deeper water as they increase in size and age, and many exhibit strong site fidelity to rocky bottoms and outcrops. Adult bocaccio are generally associated with hard substrate, but will move into mud flats.

5.8.3 Species Occurrence in Action Areas

5.8.3.1 North Seattle/Puget Sound, Elliott Bay, and South Seattle/Puget Sound

Bocaccio occurrence in the Georgia Basin is limited to certain areas. Bocaccio made up 8% to 9% of the Puget Sound recreational catch in the late 1970s, with the majority of the fish caught in the areas around Point Defiance and the Tacoma Narrows in the South Basin. Bocaccio are rare in the North Puget Sound.

Adult bocaccio have been documented within Elliott Bay (Washington et al., 1978, WDFW unpublished data, Dinnel et al., 1986). Portions of the City of Seattle shoreline, including Elliott Bay, that support kelp will also support juvenile bocaccio, particularly during spring and summer. Larval rockfish have been document within Elliott Bay, but were not documented to species (Waldron 1972). Larvae bocaccio could occur within the action areas throughout the year.

5.9 Canary Rockfish

5.10.1 Listing and Critical Habitat Designation

Canary rockfish (*Sebastes pinniger*) were listed as threatened under the ESA on April 28, 2010 (75FR22276). NMFS determined that canary rockfish is comprised of two DPSs that qualify as species under the ESA; coastal and Georgia Basin DPS. NMFS listed the Georgia Basin DPS.

Critical habitat for canary rockfish was designated on November 13, 2014 (79 FR 68041). Both nearshore and deepwater marine waters were identified as critical habitat for canary rockfish. Nearshore critical habitat is defined from the extreme high water out to a depth no greater than 30 m (98 ft) relative to mean lower low water. Deepwater critical habitat for occurs from depths greater than 30 m (98 ft).

Juvenile canary rockfish settlement habitats located in the nearshore with substrates such as sand, rock and/or cobble compositions that also support kelp are essential for conservation because these features enable forage opportunities and refuge from predators and enable behavioral and physiological changes needed for juveniles to occupy deeper adult habitats. Several attributes of these sites determine the quality of the area and are useful in considering the conservation value of the associated feature and in determining whether the feature may require special management considerations or protection. The following are the two (2) PCEs for canary rockfish nearshore critical habitat:

- Quantity, quality, and availability of prey species to support individual growth, survival, reproduction, and feeding opportunities; and
- Water quality and sufficient levels of dissolved oxygen to support growth, survival, reproduction, and feeding opportunities.

Adult canary rockfish deepwater benthic habitats and sites deeper than 30 m (98 ft) that possess or are adjacent to areas of complex bathymetry consisting of rock and or highly rugose habitat are essential to conservation because these features support growth, survival, reproduction, and feeding opportunities by providing the structure for rockfish to avoid predation, seek food and persist for decades. Several attributes of these sites determine the quality of the habitat and are useful in considering the conservation value of the associated feature, and whether the feature may require special management considerations or protection. The following are the three (3) PCEs for canary rockfish deepwater critical habitat:

- Quantity, quality, and availability of prey species to support individual growth, survival, reproduction, and feeding opportunities;
- Water quality and sufficient levels of dissolved oxygen to support growth, survival, reproduction, and feeding opportunities; and
- The type and amount of structure and rugosity that supports feeding opportunities and predator avoidance.

5.9.2 Species Information

5.9.2.1 Life History

Canary rockfish were once considered fairly common in the greater Puget Sound area. Canary rockfish maturity ranges from 3 to 13 years of age. Females produce between 260,000 and 1.9 million eggs per year. Fertilization begins in September. In Washington, parturition, birth of young, is between September and March with peaks in December and January.

Canary rockfish tend to move to deeper water as they grow larger. They can be both transient and resident. Transient canary rockfish have been found to move up to 435 mi (700 km) over several years. There is also some seasonal migration where canary rockfish can be found at depths of 525 to 689 ft (160 to 210 m) in winter to 328 to 558 ft (100 to 170 m) in summer.

Larvae are planktivores feeding on nauplii and other invertebrate eggs and copepods. Juveniles are zooplanktivores feeding on crustaceans, barnacle cyprids, and euphasiid eggs and larvae. Adults are planktivores/carnivores consuming euphasiids and other crustacean and small fish. Predators on juvenile canary rockfish include other fishes, lingcod, cabezon and salmon, as well as birds and porpoise.

5.9.2.2 Factors for Decline

The primary factors responsible for the decline of the Georgia Basin DPS of canary rockfish are overutilization for commercial and recreational purposes, water quality problems including low dissolved oxygen, and inadequacy of existing regulatory mechanisms. Specific risks to canary rockfish include:

- Low dissolved oxygen
- Continued losses as by-catch in commercial and recreational harvest
- Loss of near shore habitat
- Chemical contamination,

5.9.2.3 Habitat Requirements

Adult canary rockfish are most common at depths of 262 to 656 ft (80 to 200 m) but have been found as deep as 1,440 ft (439 m). Juveniles are found in the intertidal, in surface water, and occasionally as deep as 2,749 ft (838 m).

Larvae and pelagic juveniles are found in the upper 328 ft (100 m) of the water column. Larvae remain in the upper water column from 1 to 4 months after which they settle to tide pools, rocky reefs, kelp beds, low rock and cobble areas. Juveniles may occur in groups near the rock-sand interface in 49 to 66 ft (15-20 m) depth during the day and then move into sandy areas at night. Juveniles remain on rocky reefs in shallower areas for up to three years before moving to deeper waters. Fish move to deeper waters as they increase in size. Adults are found on the rocky shelf and pinnacles.

5.9.3 Species Occurrence in Action Areas

5.9.3.1 North Seattle/Puget Sound, Elliott Bay, and South Seattle/Puget Sound

Canary rockfish were consistently observed in the recreational catch in the mid-1960s. Canary rockfish were 1-2% of the catch in Puget Sound Proper (south of Admiralty Inlet) and 2-5% in north Puget Sound. Canary rockfish have become less frequent in the recreational catch since 1965. From 1980-1989, they were reported at a frequency of 1.1% and 1.4% in south and north Puget Sound respectively. From 1996-2001, they were reported at frequencies of less than 0.73%.

Canary rockfish have been documented in the Strait of Georgia, but most research focuses on the areas west of Vancouver Island and in Queen Charlotte Strait. Adult canary rockfish have been documented within Elliott Bay (Washington et al., 1978, WDFW unpublished data, Dinnel et al., 1986). Portions of the shoreline of Elliott Bay that support kelp will also support juvenile canary rockfish, particularly during spring and summer. Larval rockfish have been document within Elliott Bay, but were not documented to species (Waldron 1972). Larvae canary rockfish could occur within Elliott Bay throughout the year.

5.10 Yelloweye Rockfish

5.11.1 Listing and Critical Habitat Designation

Yelloweye rockfish (*Sebastes ruberrimus*) were listed as threatened under the ESA on April 28, 2010 (75FR22276). NMFS determined that yelloweye rockfish is comprised of two DPSs that qualify as species under the ESA; coastal and Georgia Basin DPS. NMFS listed the Georgia Basin DPS.

No nearshore critical habitat has been proposed for yelloweye rockfish. Adult and juvenile yelloweye rockfish deepwater benthic habitats and sites deeper than 30 m (98 ft) that possess or are adjacent to areas of complex bathymetry consisting of rock and or highly rugose habitat are essential to conservation because these features support growth, survival, reproduction, and feeding opportunities by providing the structure for rockfish to avoid predation, seek food and persist for decades. Several attributes of these sites determine the quality of the habitat and are useful in considering the conservation value of the associated feature, and whether the feature may require special management considerations or protection. The following are the three (3) PCEs for yelloweye rockfish deepwater critical habitat:

- Quantity, quality, and availability of prey species to support individual growth, survival, reproduction, and feeding opportunities;
- Water quality and sufficient levels of dissolved oxygen to support growth, survival, reproduction, and feeding opportunities; and
- The type and amount of structure and rugosity that supports feeding opportunities and predator avoidance.

5.10.2 Species Information

5.10.2.1 Life History

Yelloweye rockfish are rare in Puget Sound. Yelloweye rockfish are internally fertilized and can store sperm for several months until fertilization occurs, commonly between the months of September and April. Birth occurs in early spring to late summer. Maturity ranges from 15 to 20 years of age. Females can produce from 1.2 to 2.7 million eggs over a reproductive season. In Puget Sound, there is evidence of at least two spawning periods per year.

Yelloweye rockfish are opportunistic feeders, targeting different food sources at different phases of their life history. Juveniles are zooplanktivores feeding on crustaceans, barnacle cyprids, and euphasiid eggs and larvae. Because adult yelloweye rockfish obtain such large sizes, they are able to handle much larger prey, including smaller yelloweye, and are preyed upon less frequently, though predation of killer whales on yelloweye rockfish has been reported. Typical prey of adult yelloweye rockfish include sand lance, gadids, flatfishes, shrimp, crabs, and gastropods.

5.10.2.2 Factors for Decline

The primary factors responsible for the decline of the Georgia Basin DPS of yelloweye rockfish are overutilization for commercial and recreational purposes, water quality problems including low dissolved oxygen, and inadequacy of existing regulatory mechanisms. Specific risks to yelloweye rockfish include:

- Low dissolved oxygen
- Continued losses as by-catch in commercial and recreational harvest
- Loss of near shore habitat
- Chemical contamination.

5.11.2.3 Habitat Requirements

Yelloweye rockfish use a broad range of depths throughout their life history. Juveniles can be found at depths of 49 ft (15 m) and adults up to 1,801 ft (549 m). Adults are most commonly found between 299 and 591 ft (91 and 180 m).

Juvenile yelloweye rockfish habitat includes shallow water, high relief zones, and crevices. Adults are associated with rocky, high relief areas. Adults have a high affiliation with caves and crevices while spending large amounts of time lying at the base of rocky pinnacles and boulder fields.

Larvae are pelagic for up to 2 months. Juvenile move from the shallow rock reefs to deeper pinnacles and rocky habitats as they get larger. Yelloweye rockfish adults are not known to migrate and are considered to be site-attached.

5.10.3 Species Occurrence in Action Areas

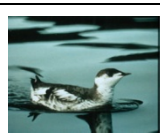
5.10.3.1 North Seattle/Puget Sound, Elliott Bay, and South Seattle/Puget Sound

Yelloweye rockfish caught in the recreational fishery in the mid-1960s were similar to the canary rockfish. Yelloweye rockfish comprised 1-2% of the catch in Puget Sound Proper and 2-5% in north Puget Sound. The frequency of yelloweye rockfish in Puget Sound Proper appears to have increased from a frequency of 0.34% in 1980-1989 to a frequency of 2.7% in 1996-2001.

Adult yelloweye rockfish have been documented within Elliott Bay (Washington et al., 1978, WDFW unpublished data, Dinnel et al., 1986). Juvenile yelloweye rockfish do not typically occupy shallow waters (Love et al., 1991) and are very unlikely to be in Elliott Bay. Larval rockfish have been documented within Elliott Bay, but were not documented to species (Waldron 1972). Larvae yelloweye rockfish could occur within Elliott Bay throughout the year.

Table 5-3 provides a quick reference for listed species and designated critical habitat within the City of Seattle action areas.

Table 5-3
Quick reference for ESA-listed species and critical habitat in the Seattle action areas. For smaller streams within the larger action area, please see appropriate section in the SBE for presence of ESA-listed species. (Shading indicates presence in action area)

		Action Area							
		Elliott Bay	Lake Washington Ship Canal	Lower Green/ Duwamish	North Seattle/ Puget Sound	North Lake Washington	Thornton Creek	South Seattle/ Puget Sound	South Lake Washington
Puget Sound Chinook Salmon 	Species								
	Critical Habitat								
Coastal-Puget Sound Bull Trout 	Species								
	Critical Habitat								
Killer Whale 	Species								
	Critical Habitat								
Humpback Whale 									
Marbled Murrelet 									

		Action Area							
		Elliott Bay	Lake Washington Ship Canal	Lower Green/ Duwamish	North Seattle/ Puget Sound	North Lake Washington		South Seattle/ Puget Sound	South Lake Washington
							Thornton Creek		
Puget Sound Steelhead 	Species								
	Critical Habitat								
Eulachon 	Species								
	Critical Habitat								
Bocaccio 	Species								
	Critical Habitat	Nearshore and Deepwater			Nearshore and Deepwater			Nearshore and Deepwater	
Canary Rockfish 	Species								
	Critical Habitat	Nearshore and Deepwater			Nearshore and Deepwater			Nearshore and Deepwater	
Yelloweye Rockfish 	Species								
	Critical Habitat	Deepwater			Deepwater			Deepwater	