Appendix H
Southern Resident Killer Whales

The Columbia River Crossing (CRC) project will likely adversely affect Chinook salmon, the chief prey base of the Southern Resident killer whale Distinct Population Segment (DPS). For this reason, the National Marine Fisheries Service (NMFS) has requested that this biological assessment (BA) assess project impacts to Southern Resident killer whales.

Current Range-Wide Status

The Southern Resident killer whale DPS consists of three pods, identified as J, K, and L pods. This section summarizes the status of the Southern Resident DPS killer whales throughout their range. Although the entire Southern Resident DPS has the potential to occur in the coastal waters of Oregon, Washington, and British Columbia at any time during the year, occurrence is more likely from November through April when Southern Residents tend to leave the inland waters of Washington State and British Columbia.

The information on the range-wide status of the species is generally representative of the status of the species in coastal waters. The final recovery plan for Southern Residents was issued in January 2008 (NMFS 2008a). This section summarizes information taken largely from the recovery plan, as well as new data that became available more recently.

Status and Trends

There are no empirical data available from which to derive estimates of historical stock size for this DPS. However, using indirect metrics (e.g., population estimates combined with estimated numbers of killer whales captured for display purposes in the 1960s and 1970s), it is possible to estimate the historical abundance of this DPS at 140-200 individuals (NMFS 2003).

At present, the Southern Resident population has declined to essentially the same size as estimated during the early 1960s, when it was considered as likely depleted (Olesiuk et al. 1990). Since censuses began in 1974, J and K pods steadily increased their sizes until 1996, and then suffered approximately a 20 percent decline from 1996 to 2001, largely due to declines in the L pod population. As of November 2009, the Southern Resident population totaled 87 individuals: 27 in J pod, 19 in K pod, and 41 in L pod (Balcomb 2009 personal communication).

Listing Status

The Southern Resident killer whale DPS was listed as endangered under the Endangered Species Act (ESA) on November 18, 2005 (NMFS 2005a). Southern Residents are designated as “depleted” and “strategic” under the Marine Mammal Protection Act (MMPA) (NMFS 2003). Critical habitat for the Southern Resident killer whale DPS was proposed on June 15, 2006 (NMFS 2006a), and the final designation of critical habitat was published November 29, 2006 (NMFS 2006b). Critical habitat includes approximately 2,560 square miles of inland waters in three specific areas: 1) the summer core area in Haro Strait and waters around the San Juan Islands; 2) Puget Sound; and 3) the Strait of Juan de Fuca. No project activities will occur within designated critical habitat; therefore, critical habitat is not considered further in this consultation.

Range and Distribution

Southern Residents are found throughout the coastal waters off Washington, Oregon, and Vancouver Island, and are known to travel as far south as central California and as far north as the Queen Charlotte Islands, British Columbia (Figure H1). Their occurrence in the action area encompasses marine areas within 50 kilometers (km) (31 miles) of the Pacific coast from southern Oregon north to the Queen Charlotte Islands in British Columbia, where they may overlap in distribution with Chinook salmon from the Columbia River.

Southern Residents are highly mobile and can travel up to 160 km (86 miles) in a single day (Erickson 1978; Baird 2001). To date, there is no evidence that Southern Residents travel farther than 50 km offshore (Ford et al. 2005). Although the entire Southern Resident DPS has the potential to occur in coastal waters at any time during the year, occurrence is more likely from November to May. From late spring to early autumn, Southern Residents spend the majority of their time in inland waterways of Washington State and British Columbia (Strait of Georgia, Strait of Juan de Fuca, and Puget Sound) (Bigg 1982; Ford et al. 2000; Krahn et al. 2002). Typically, J, K, and L pods arrive in May or June and spend most of their time in the core area of the Georgia Basin and Puget Sound, until departing in October. K and L pods also make frequent trips to the outer coasts of Washington and southern Vancouver Island during this time; these trips generally last a few days (Ford et al. 2000).

Late summer and early fall movements of Southern Residents in the Georgia Basin have remained fairly consistent since the early 1970s, with strong site fidelity shown to the region as a whole. However, presence in inland waters in the fall has increased in recent years (NMFS 2008a). It is uncertain whether potential variability in sighting efforts over time has contributed to this trend. During early autumn, Southern Residents, and J pod in particular, expand their routine movements into Puget Sound, likely to take advantage of chum and Chinook salmon runs (Osborne 1999). During late fall, winter, and early spring, the ranges and movements of Southern Residents are less well known. Sightings in the Strait of Juan de Fuca in late fall suggest that activity shifts to the outer coasts of Vancouver Island and Washington at that time (Krahn et al. 2002).

Southern Residents were formerly thought to range southward along the coast to about Grays Harbor (Bigg et al. 1990) or the mouth of the Columbia River (Ford et al. 2005). However, recent sightings of members of K and L pods in Oregon (in 1999 and 2000) and California (in 2000, 2003, 2005, 2006, and 2008) have considerably extended the southern limit of their known range (NMFS 2008a). There have been 40 verified sightings or strandings of J, K, or L pod members along the outer coast from 1975 to present, with most sightings occurring from January to May. These include 16 records off Vancouver Island and the Queen Charlottes, 11 off Washington, 4 off Oregon, and 9 off central California. Most records have occurred since 1996, but this is more likely because of increased viewing efforts along the coast for this time of year. Sightings in Monterey Bay, California, coincided with large runs of salmon, with feeding witnessed in 2000 (Black et al. 2001). In March 2004, L pod was also seen feeding on unidentified salmon off Westport, Washington, during the spring Chinook run in the Columbia River (M.B. Hanson, personal observation, as cited in Krahn et al. 2004).

Life History

Southern Resident killer whales are a long-lived species, with late onset of sexual maturity (review in NMFS 2008a). Females produce a low number of surviving calves over the course of their reproductive life span (5.4 surviving calves over 25 years) (Bain 1990; Olesiuk et al. 1990). Mothers and offspring maintain highly stable social bonds throughout their lives, which is the basis for the matrilineal social structure in the Southern Resident population (Bigg et al. 1990; Ford et al. 2000; Baird 2001). Groups of related matrilines form pods. Clans are composed of pods with similar vocal dialects; all three pods of the Southern Residents are part of J clan.

Figure H1. Southern Resident Killer Whale DPS Distribution

Biological Assessment Columbia River CROSSING

Analysis by J. Koloszar; Analysis Date: Nov. 2009; File Name: KillerWhaleDist_JL194.mxd

Studies of the late spring, summer, and fall dietary preferences of resident killer whales in the northeastern Pacific indicate that their prey base includes 22 species of fish and one species of squid (Scheffer and Slipp 1948; Ford et al. 1998; Ford et al. 2000; Ford and Ellis 2006; Saulitis et al. 2000, as cited in NMFS 2008a). Little is known about the winter and early spring foods of Southern and Northern Residents, or whether individual pods have specific dietary preferences or have shifted preferences for different prey species over time.

Limited data are available on the dietary preferences specific to the Southern Resident population; however, feeding records suggest that dietary preferences of this DPS are similar to those documented for killer whales of Northern Resident populations. Southern Residents exhibit a strong preference for Chinook salmon (78 percent of identified prey) during late spring to fall (Hanson et al. 2007; Ford and Ellis 2006). Chum salmon (11 percent) are also taken in significant amounts, especially in autumn. Other salmon prey include coho (5 percent), sockeye (1 percent), and non-salmonids (e.g., Pacific herring and quillback rockfish [*Sebastes maliger*], 3 percent combined) (NMFS 2008a). Chinook were preferred despite the much lower abundance of Chinook in the study area in comparison to other salmonids, probably because of the species' large size, high fat and energy content, and year-round occurrence in the area. Killer whales also captured older (i.e., larger) than average Chinook (Ford and Ellis 2006). Ongoing research continues to identify prey of Southern Residents through direct observation and scale sampling. More recently, researchers have started collecting fecal samples for analysis to address the potential biases of scale sampling. Although studies and analyses are not yet complete, preliminary results of ongoing sampling efforts are the best available information on the diet composition of Southern Residents.

Southern Residents concentrate in their core summer area in the San Juan Islands (particularly on the west side of San Juan Island) from May to September. This area is considered a central area for feeding (Baird and Hanson 2004; Hauser 2006). During these months, their diet consists of approximately 86 percent Chinook salmon and 14 percent other salmon species (n=125 samples; Hanson et al. 2007; Northwest Fisheries Science Center [NWFSC] unpublished data). Sampling indicates an apparent shift to chum salmon in the fall months when some Southern Residents have been sighted inside Puget Sound (Hanson et al. 2007). Early results from genetic analysis of fecal and prey samples indicate that Southern Residents consume Fraser River-origin Chinook, as well as salmon from Puget Sound, Washington, and Oregon coasts, the Columbia River, and the Central Valley of California (Hanson et al. 2007). As further data are analyzed, they will provide information on which specific runs of salmon the whales are consuming in specific locations and seasons.

Although less is known about diet preferences of Southern Residents off the Pacific Coast, it is likely that salmon are also important during late fall and winter when Southern Residents more predictably occur in coastal waters. Based on the best available information, Southern Residents may also prefer Chinook salmon when these are available in coastal waters. Chemical analyses support the importance of salmon in the year-round diet of Southern Residents (Krahn et al. 2002, 2007). Krahn et al. (2002) examined the ratio of dichlorodiphenyltrichloroethane (DDT) (and its metabolites) to various polychlorinated biphenyl (PCB) compounds in the whales, and concluded that the whales feed primarily on salmon rather than other fish species throughout the year. Krahn et al. (2007) analyzed stable isotopes from tissue samples collected in 1996 and 2004/2006. Carbon and nitrogen stable isotopes indicated that J and L pods consumed prey from similar trophic levels in 2004/2006, and showed no evidence of a large shift in the trophic level of prey consumed by L pod between 1996 and 2004/-2006.

Researchers have estimated the energy requirements of killer whales and caloric values for salmon to calculate the number of fish needed per day. Salmon differ significantly in size across species and runs, and prey preference among salmon would affect annual consumption rates. Fewer salmon per day would be required from a larger preferred prey species such as Chinook salmon. NMFS provides an estimate of the biological requirements of Southern Residents using the best available information on metabolic

needs of the Southern Resident population and the caloric content of salmon (i.e., NMFS 2008b; NMFS 2008d; see Prey Availability section below).

Environmental Baseline

Because the Southern Resident DPS is found in coastal waters during some portion of the year, the status of the species in this area is the same as the range-wide status of the species, described above. The following discussion summarizes the conditions in coastal waters that are known to affect the likelihood that Southern Resident killer whales will survive and recover in the wild. The small size of the population increases the level of concern about any risks to Southern Resident killer whales (NMFS 2008a).

Natural Mortality

Seasonal mortality rates among Southern and Northern Resident killer whales are believed to be highest during the winter and early spring, based on the numbers of animals missing from pods that return to inland waters each spring. Olesiuk et al. (2005) identified a high neonate mortality that occurred outside of the summer field research seasons. Stranding rates are higher in winter and spring for all killer whale eco-types in Washington and Oregon (Norman et al. 2004).

Natural mortality in some cases may be attributed to poor nutritional condition. In recent years, some observations have been made of underweight killer whales returning to inland waters in the spring. For example, in March 2006 a female in poor body condition from the Southern Resident population (L54) with a nursing calf was sighted off Westport, Washington. The sighting report indicated she had lost so much blubber that her ribs were showing under the skin (Cascadia Research Collective 2008).

Prey Availability

Salmon, particularly Chinook salmon, are the preferred prey of Southern Resident killer whales in inland waters of Washington State during spring, summer, and early fall (Baird and Hanson 2004; Hauser 2006). Chemical analyses support the importance of salmon in the year-round diet of Southern Residents. In offshore areas, killer whales may also feed on squid, sharks, halibut, and migratory fish (Krahn et al. 2004; Jones 2006). When prey abundance is low, killer whales may spend more time and energy foraging than when prey abundance is high; potential consequences for fitness include reduced reproductive rates and higher mortality rates. Ford and Ellis (2006) correlated coast-wide reduction in Chinook abundance (Alaska, British Columbia, and Washington) with decreased survival of resident whales (Northern and Southern Residents), but changes in killer whale abundance have not been linked to local areas or changes in salmon stock groups. No recent changes in salmon populations are obviously apparent that might be responsible for the recent decline in the Southern Resident population between 1996 and 2001 (NMFS 2008b). However, potential prey limitation is an area of ongoing research.

A number of natural and human-caused factors affect the availability of prey for Southern Resident killer whales. Details regarding range-wide status of federally listed Chinook salmon in the Columbia River basin are described in Section 4 and Appendix C of this BA. Adult salmon are also affected by fisheries harvest in fresh and marine waters. In addition, climate effects from Pacific decadal oscillation and El Nino/Southern oscillation conditions and events cause changes in ocean productivity, which can affect natural mortality of salmon. Predation in the ocean also contributes to natural mortality of salmon.

Salmonids are prey for pelagic fishes, birds, marine mammals, and terrestrial mammals. The abundance of Chinook stocks across the coastal range of Southern Residents varies on an annual basis due to a combination of factors, including ocean conditions and harvest management decisions (e.g., NMFS 2008b). For example, recent consultation on the Pacific Salmon Plan estimated there may have been approximately 1.2 million adult Chinook salmon available in the coastal range of Southern Residents during the 2008-2009 regulatory cycle (NMFS 2008c). NMFS found that Pacific Fishery Management

Council salmon fisheries harvest during the 2008-2009 regulatory cycle would cause a negligible reduction in prey resources, with no detectible change in the ratio of prey availability to needs for Southern Residents within their coastal range (NMFS 2008c). This estimate includes estimated annual reductions in prey availability from fisheries harvest in coastal waters.

A downward trend in size and age is generally applicable in many salmon populations (Quinn 2005). Size of individual salmon could affect the number of prey required by Southern Residents. Fish size is influenced by factors such as environmental conditions, selectivity in fishing effort through gear type, fishing season or regulations, and hatchery practices. There is some evidence of a decrease over time in salmon size, or size at a given age; Bigler et al. (1996) found a decreasing average body size in 45 of 47 salmon populations in the Northern Pacific.

Based on the best available information regarding diet composition for Southern Resident killer whales, their metabolic needs, and the caloric content of salmon, NMFS estimates that the Southern Resident population (based on 2007 population size and structure) needs approximately 221,000 Chinook on an annual basis in coastal waters of their range (NMFS 2008c). Whether the whales' metabolic needs can be equally satisfied by hatchery fish versus wild fish depends on a comparison of the ocean distribution, run timing, and size of hatchery fish versus wild fish. Southern Resident killer whales consume both natural and hatchery salmon (Barre 2008). Hatchery fish may differ from natural fish; however, the best available information indicates that the ocean distribution, run timing, and size of hatchery and wild salmon does not follow a general pattern but is case-specific, with differences apparent in some populations but not in others (NMFS 2008b). Therefore, the best available information does not indicate general differences in size, run timing, or ocean distribution of hatchery and wild salmon for stocks available to Southern Residents across their range.

Prey Quality

Contaminants enter fresh and marine waters and sediments from numerous sources, but are typically concentrated near populated areas of high human activity and industrialization. Recent studies have documented high concentrations of PCBs, DDTs, and polybrominated diphenyl ethers (PBDEs) in killer whales (Ross et al. 2000; Ylitalo et al. 2001; Reijnders and Aguilar 2002; Krahn et al. 2004). As top predators, when killer whales consume contaminated prey they accumulate the contaminants in their blubber. When prey is scarce, killer whales metabolize their blubber and the contaminants are mobilized (Krahn et al. 2002). The mobilized contaminants can reduce the whales' resistance to disease and can affect reproduction. Nursing females transmit large quantities of contaminants to their offspring (NMFS 2008a).

Chinook salmon contain higher levels of some contaminants (i.e., PCBs) than other salmon species (O'Neill et al. 2005). Only limited information is available for contaminant levels in Chinook along the west coast. Higher PCB and PBDE levels may distinguish Puget Sound-origin stocks, whereas a higher DDT signature may distinguish California-origin stocks (Krahn et al. 2007). Adult Chinook that originate from the Columbia River basin could accumulate contaminants through development and growth in the freshwater and marine environment, and thus become a source of contaminants for Southern Residents.

Vessel Activities and Sound

Killer whales can be affected by the physical presence of vessels and by the sound the vessels generate. Several studies in the inland waters of Washington State and British Columbia have observed changes in killer whale behavior in the presence of vessels (Kruse 1991; Williams et al. 2002a,b; Foote et al. 2004; Bain et al. 2006). These behavioral changes can affect the whales' foraging efficiency and the amount of energy they expend in migrating, foraging, and other activities. Sound from vessels can also interfere with communication and prey location.

Killer whales rely on their highly developed acoustic sensory system for navigating, locating prey, and communicating with other individuals. Increased levels of anthropogenic sound have the potential to mask echolocation and other signals, as well as to temporarily or permanently damage hearing sensitivity. Exposure to sound may therefore impair foraging and other behavior essential for survival (Bain and Dahlheim 1994; Gordon and Moscrop 1996; Erbe 2002; Williams et al. 2002a,b). There is evidence that underwater vessel noise can significantly reduce the range at which echo-locating killer whales can detect salmon in the water column (Holt 2008). In other cetaceans, hormonal changes indicative of stress have been recorded in response to intense sound exposure (Romano et al. 2003). Chronic stress is known to induce harmful physiological conditions (such as reducing immune response) in terrestrial mammals, and may have the same effect in cetaceans (Gordon and Moscrop 1996).

Killer whale hearing sensitivity ranges from 1 to 120 kHz, with peak sensitivities from 20 to 50 kHz (Szymanski et al. 1999), and fully covers the bandwidth generally considered as mid-frequency (2 to 10 kHz). However, the threshold levels at which underwater sounds negatively impact killer whale hearing and behavior are not well understood (Krahn et al. 2002).

The Southern Resident DPS has been exposed to sound generated by whale-watching vessels in the summer core area (particularly Puget Sound and Haro Strait) since the early 1990s (Bain 2002). Whale-watching vessels can produce high levels of underwater sound in proximity to the animals; as a result, whale-watching has been cited as an important potential contributing factor in the recent decline of this population (Baird 2001; Krahn et al. 2002; Wiles 2004).

Recreational fishing boats are common in the summer core area. When operating at slow speeds or in idle, these boats usually do not appear to disrupt the whales' behavior (Krahn et al. 2004).

Commercial shipping traffic is a major source of low-frequency (5 to 500 Hz) human-generated sound. Several thousand trips are made per month by various types of commercial through the summer core area for this DPS (NMFS 2008a). Although large vessels have predominantly low-frequency sound, studies have reported broadband sounds from large cargo ships at significant levels of noise above 2 kHz that may interfere with important biological functions (Hildebrand et al. 2006, summarized in Holt 2008).

Non-Vessel Sound

Human-generated sound in coastal waters within the range of Southern Residents is caused by sources other than vessels, including oil and gas exploration, construction activities, and military operations. Natural sounds in the marine environment include wind, waves, surf noise, precipitation, thunder, and biological noise from other marine species. The intensity and persistence of certain sounds (both natural and anthropogenic) in the vicinity of marine mammals vary by time and location and have the potential to interfere with important biological functions (e.g., hearing, echolocation, communication). Sound from in-water construction activities could potentially occur through permits issued by the U.S. Army Corps of Engineers under Section 404 of the Clean Water Act and Section 10 of the Rivers and Harbors Act of 1899 and by the State of Washington under its Hydraulic Project Approval (HPA) program. Several consultations on federal projects in the coastal range of Southern Residents have been conducted and conservation measures have been included to minimize or eliminate potential effects to marine mammals. Sound, such as sonar generated by military vessels, also has the potential to disturb killer whales in coastal waters. The impacts of military mid-frequency sonar on killer whales have not been directly studied; however, behavioral changes in members of the Southern Resident DPS have been observed in the presence of mid-frequency sonar training exercises in Puget Sound (NMFS 2008a). As with vessel sounds, there are likely minor effects on killer whales in the ocean from anthropogenic sounds because of the vastness of the area and low density of sound sources.

Oil Spills

Oil spills have occurred in the coastal range of Southern Residents in the past, and there is potential for spills in the future. Oil can be discharged into the marine environment from a number of sources, including shipping accidents, refineries and associated production facilities, and pipelines. The coastal range of Southern Residents is primarily at risk from shipping accidents involving transiting oil tankers.

Southern Residents may also be affected by long-term repeated ingestion of sub-lethal quantities of petroleum hydrocarbons, although the effects are not well understood. In marine mammals, acute exposure to petroleum products can cause changes in behavior and reduced activity, inflammation of the mucous membranes, lung congestion, pneumonia, liver disorders, and neurological damage (Geraci 1990; Wursig 1990). In addition, oil spills have the potential to adversely impact habitat and prey populations, and, therefore, may adversely affect Southern Residents by reducing food availability.

Scientific Research

Most of the scientific research conducted on Southern Resident killer whales occurs in inland waters of Washington State and British Columbia. In general, the primary objective of this research is population monitoring or data gathering for behavioral and ecological studies. Research activities are typically conducted between May and October in inland waters; however, some research is conducted in coastal waters.

NMFS determined that the effects of research-associated disturbances on Southern Residents were likely to adversely affect, but not jeopardize the continued existence of, Southern Resident killer whales (NMFS 2006c). The annual authorized takes by harassment of Southern Residents under research permits issued by NMFS in 2006 totaled 1,935 non-invasive takes (e.g., surveys and photo-identification); 70 takes from biopsying, tagging, or breath sampling; and 820 takes due to unintentional harassment, although actual anticipated takes are substantially lower. While most of the authorized takes would occur in inland waters, a small portion of this disturbance is part of the baseline in the coastal range of Southern Residents.

Activities Outside U.S. Jurisdiction

The Southern Resident killer whales are highly migratory and may transit between U.S., Canadian, and international waters. Data are not presently available to assess the impact on Southern Residents of scientific research or boating activities within Canadian or international waters. NMFS included information on Canadian fisheries within the coastal range of Southern Residents, using the same methods as those used to quantify U.S. fisheries information for this area (NMFS 2008d).

Summary of the Environmental Baseline

Southern Resident killer whales are exposed to a wide variety of past and present state, federal, and private actions in their coastal range; to federal projects in this area that have already undergone formal Section 7 consultation; and to state or private actions that are contemporaneous with this consultation. All of the activities discussed in the above section are likely to have some level of impact on Southern Residents when they are in coastal waters. Reductions in food availability, increased exposure to pollutants, and human disturbance have all been identified as potential threats to killer whales in Washington and British Columbia (Ford and Ellis 1999, 2005; Ford et al. 2000; Baird 2001; Krahn et al. 2002, 2004; Taylor 2004; Wiles 2004). Researchers are unsure about which threats are most significant to the Southern Resident population, and none of the threats have been identified as the cause of the recent decline of the Southern Resident population (Krahn et al. 2002). There is limited information on how these factors or additional unknown factors may be affecting Southern Resident killer whales in coastal

waters in winter. It is possible that two or more of these factors may act together to harm the whales. The small size of the population increases the level of concern for all of these risks (NMFS 2008a).

Effects of the Proposed Action on Southern Resident Killer Whales

The potential effects of the CRC project on Southern Resident killer whales relate to prey availability only. Chapter 3 of this BA describes the CRC project, as well as any interdependent and interrelated actions (see Section 3.14).

The project will have no direct effects on killer whales. However, the project will expose killer whales to indirect effects by potentially decreasing the abundance of killer whale prey in the ocean. Changes in prey abundance could affect the entire DPS of Southern Resident killer whales. The best available information indicates that salmon are the preferred prey of killer whales year-round (Krahn et al. 2002, 2007), including while in coastal waters, and that Chinook are the preferred salmon species (Ford and Ellis 2006). Prey abundance is a concern for killer whales, both near-term and long-term. To survive in the near term, killer whales require regular supplies of adult Chinook prey in the ocean. To recover over the longer term, killer whales require abundant Chinook stocks coast-wide, likely including stocks from the Columbia River. Any indirect effects to Southern Resident killer whales would be expressed via effects to the prey base.

This analysis considers the short-term and long-term effects of the CRC project.

Short-term Effects on Southern Resident Killer Whales

The project will result in short-term effects to the killer whale prey base during construction. Section 6 of this BA and Appendix K (Hydroacoustics Technical Report) detail the means by which the project may affect and is likely to adversely affect Chinook. In summary, adverse effects of the project on Chinook include in-water noise and vibration, construction-related turbidity, contaminants contained in stormwater runoff, direct handling of fish, short-term physical loss and alteration of fish habitat during construction, and long-term habitat loss from placement of the new bridge structures. Project response to short- and long-term losses to habitat will include measures to assist in the recovery of listed species.

For assessment of effects of CRC project activities on Southern Resident prey we assume, first, that the primary mechanism of effect is the reduction in the population of outmigrants passing through the project area. Reduction of recruits to the Southern Resident prey base by loss of spawning adults is possible but is dependent on such complex and variable life stage survival rates (e.g., egg to alevin to fry) that effects on adult salmon must be considered *de minimis*. The second assumption is that survival to prey size is approximately 5 percent, based on a conservative estimate of the smolt-to-adult survival ratio of 3.1 percent for Chinook as reported by Quinn (2005)[1]. Third, we assume the effects attributable to the CRC project are equally distributed across all outmigrants and all populations, even those not affected by the project. It follows, then, that a maximum-effect estimate of reduction in prey availability could be obtained by applying the project effect (the proportion of any run likely impacted), discounted by 95 percent, to annual salmon returns to the Columbia River (the 5 percent that would have survived to become prey and/or return).

The largest percentage of impact to any juvenile Chinook population moving through the CRC project in one year is 0.08 percent (Section 6). Through discounting, the maximum loss of prey is estimated at 0.004 percent of the annual Columbia River salmon return for 1 year. The average impact over 4 years is less than 0.02 percent per year, which represents 0.001 percent per year after discounting. Minimum estimates

[1] Smolt-to-adult survival can range from 1.4 percent for chum salmon and 3.1 percent for Chinook to 10.4 percent for coho and as much as 13.0 percent for steelhead, based on estimates collected by Quinn (2005)

of Chinook and coho salmon originating in Columbia River range from approximately 442,900 to 1,843,200 per year for a recent 10-year period (JCRMS 2009, 2010). Using this range, and excluding all other Pacific salmon and other prey species, an average of four to 18 fish of prey size per year might be removed from the Southern Resident salmon prey base if all effects were lethal over the 4-year construction period. To put this in context, consider that NMFS found that salmon fisheries conducted during the 2008-2009 regulatory cycle would cause a negligible reduction in prey resources, with no detectible change in the ratio of prey availability to needs for Southern Residents within their coastal range (NMFS 2008c). This estimate includes estimated annual reductions in prey availability from fisheries harvest in coastal waters. Seasonal harvest of Chinook and coho salmon by treaty and non-Indian fishers in the United States and Canada/Cape Falcon area ranged from 20,100 to 106,400 and 19,100 to 92,800, respectively, in the last 10 years (PFMC 2010). Taking the minimal number of salmon potentially attributable to Project effects together with NMFS finding for vastly larger removal of prey by fishers, it is reasonable to conclude that the reduction in prey due to project effects is negligible and not likely to adversely affect Southern Residents.

The Southern Resident population of killer whales is not present in the Columbia River. In-water construction will occur at river mile (RM) 106; therefore, killer whales will have no exposure to the following project elements: hydroacoustic impacts, construction-related vessel traffic, passage barriers from project construction, or potential water quality impacts.

Indirect effects to Southern Resident killer whales would be expressed through effects to Chinook and other salmon species comprising the prey base. These indirect effects include stormwater effects on water quality in the Columbia River, and land use and traffic changes. As discussed in Section 6.2, exposure of Chinook and other salmon to stormwater and degraded water quality will be minimal; the high level of stormwater treatment is expected to provide an overall benefit to the environmental baseline. As also discussed in Section 6.2, land use and traffic changes are not likely to adversely affect Chinook or other salmonids discussed in this BA. Therefore, any indirect effects to killer whales are anticipated to be negligible as a result of this project.

There are expected to be no effects to the Southern DPS of killer whales associated with interdependent and interrelated actions.

Long-term Effects on Southern Resident Killer Whales

The project will have no significant long-term negative effects on the Southern Resident killer whale prey base. Therefore, there will be no long-term negative effects on the Southern Resident killer whale.

Effects Determination

The project **may affect** the Southern Resident DPS of killer whales because:

- The project will have adverse effects on the Chinook prey base of the Southern Resident DPS. Refer to Section 6 of this BA for a full analysis of effects to Chinook salmon.

The project is **not likely to adversely affect** the Southern Resident DPS because:

- The project will adversely impact less than 0.13 percent of the Columbia River Chinook salmon population for a period of no more than 1 year and average less than 0.02 percent over 4 years. This represents an extremely small percentage of the entire population occurring in the marine portion of the action area. In addition, project-sponsored conservation measures will result in larger Chinook population numbers in the long term. Therefore, the resulting impact to the Chinook prey base is insignificant.

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