B0090

**DEPARTMENT OF THE ARMY**
**CORPS OF ENGINEERS, NORTHWESTERN DIVISION**
**PO BOX 2870**
**PORTLAND OR 97208-2870**

REPLY TO
ATTENTION OF

Planning, Environmental Resources,
Fish Policy, and Support Division

Mr. D. Robert Lohn
Regional Administrator
National Oceanic and Atmospheric Administration
National Marine Fisheries Service
Northwest Region
7600 Sand Point Way N.E., Bldg. 1
Seattle, WA 98115

Bob

Dear ~~Mr. Lohn~~:

The U.S. Army Corps of Engineers (Corps), the Bureau of Reclamation (Reclamation), and Bonneville Power Administration (BPA) (collectively termed the Action Agencies) are responsible for consulting with the National Marine Fisheries Service (NMFS) on proposed Federal actions that may affect species listed under the Endangered Species Act (ESA). In August 2007, the Action Agencies submitted several documents for NMFS' consideration pursuant to the ESA. These documents addressed the effects on listed anadromous fish of both the Federal Columbia River Power System (FCRPS), and mainstem effects of other tributary actions and Reclamation's operations and maintenance in the Snake River Basin above Brownlee Reservoir. In response to comments on the draft *2007 Federal Columbia River Power System Biological Opinion* (NMFS 2007a) and draft *2007 Upper Snake River Biological Opinion* (NMFS 2007b), NMFS requested that the Action Agencies consider whether the proposed actions may affect either the Southern Resident distinct population segment (DPS) of killer whales or the Southern DPS of green sturgeon, in addition to the listed anadromous salmonids. On behalf of the Action Agencies, I am submitting the enclosed *Addendum to the "Comprehensive Analysis of the Federal Columbia River Power System and Mainstem Effects of Upper Snake and Other Tributary Actions" - Analysis of Effects on Listed Killer Whale and Green Sturgeon Populations* to address the effects of the FCRPS and Upper Snake River actions on these two additional species.

The Action Agencies have made a determination in the addendum that the proposed actions may affect, but are not likely to adversely affect the Southern Resident DPS of killer whales or the Southern DPS of green sturgeon. We have also determined that there is no effect to Southern Resident killer whale DPS critical habitat. Based on this analysis, we are requesting concurrence on our determinations of effect for the Southern Resident DPS of killer whales and Southern DPS of green sturgeon.

I am forwarding a copy of this letter to Stephen J. Wright, Bonneville Power Administration, and William McDonald, U.S. Bureau of Reclamation. The Action Agencies are available to address issues and concerns regarding this Addendum. Please feel free to contact David Ponganis (Corps) at 503-808-3828, Kathryn Puckett (Reclamation) at 208-378-5089, or Sarah McNary (BPA) at 503-230-5135 (BPA) if you have any questions.

Sincerely,

Witt Anderson
Director, Programs

Enclosure

# Addendum to the "Comprehensive Analysis of the Federal Columbia River Power System and Mainstem Effects of Upper Snake and Other Tributary Actions"

# Analysis of Effects on Listed Killer Whale and Green Sturgeon Distinct Population Segments


Federal Action Agencies

**Bureau of Reclamation**

**U.S. Army Corps of Engineers**

**Bonneville Power Administration**


**April 2008**

## I. INTRODUCTION

After receiving comments on the draft *2007 Federal Columbia River Power System (FCRPS) Biological Opinion* (NMFS 2007a) and draft *2007 Upper Snake River Biological Opinion* (NMFS 2007b), NMFS requested that the Federal Action Agencies consider whether the proposed reasonable and prudent alternative (RPA) for the FCRPS Biological Opinion and the proposed action for the Upper Snake River Biological Opinion may affect either the ESA-listed Southern Resident distinct population segment (DPS) of killer whales (orcas) or the ESA-listed Southern DPS of green sturgeon, in addition to the listed anadromous salmonids. We have prepared this addendum to the Comprehensive Analysis to evaluate the effects of the FCRPS and Upper Snake River actions on these two additional listed species.

## II. DESCRIPTION OF THE ACTION

The description of the action for this addendum is the same as those for the FCRPS Anadromous Salmonid Biological Assessment (BA) (USACOE et al. 2007) and the Upper Snake River BA (USBR 2007).

**FCRPS projects:** The proposed action for the FCRPS, a system of 14 multipurpose hydropower projects, takes the form of a "Reasonable and Prudent Alternative." It addresses actions in several areas: hydropower; habitat; hatcheries; harvest; predation management; and research, monitoring, and evaluation. The proposed Reasonable and Prudent Alternative, submitted by all three Action Agencies, is to cover a 10-year period. The detailed description of the proposed action can be found in Chapter 2 of the FCRPS Anadromous Salmonid BA (USACOE et al. 2007), and is incorporated here by reference. The following is a short summary of the FCRPS RPA from *NOAA Fisheries' Executive Summary FCRPS and Upper Snake Biological Opinions* (NMFS 2007c):

> "The Reasonable and Prudent Alternative for the FCRPS takes an all-H approach to ESA protections - including hydro, habitat, hatcheries and harvest measures - to address the biological needs of salmon and steelhead in every life stage. The Action Agencies emphasize that their proposal is the product of the collaboration and is based on a comprehensive analysis of the salmon lifecycle conducted down to the level of the populations that comprise the listed species.
>
> The Reasonable and Prudent Alternative outlines planned improvements to the hydrosystem to boost juvenile passage survival and adult returns. These actions include water management operations, dam modifications, spill, juvenile transportation and other activities. With regard to habitat, the Reasonable and Prudent Alternative proposes an expanded program to protect and improve tributary and estuary environments within the Columbia River basin based on the biological needs of listed fish, to reduce limiting factors.
>
> The Reasonable and Prudent Alternative proposes new and expanded hatchery facilities for safety-net and conservation programs that promote salmon and steelhead recovery. The proposal includes actions to increase steelhead productivity and to support hatchery reforms that reduce impacts on listed fish.

Predation management is another element in the Reasonable and Prudent Alternative. The proposal is to expand efforts to reduce juvenile and adult losses due to predation by birds, fish and marine mammals.

To gauge the effectiveness of the actions and to explore areas of scientific and biological uncertainty, the FCRPS Reasonable and Prudent Alternative establishes performance standards and outlines a research, monitoring and evaluation program. The Action Agencies propose to adapt their efforts based on new information and the results of monitoring and evaluation."

**Upper Snake Projects:** The proposed action for the Upper Snake River Projects takes the form of operations and routine maintenance activities for Federal irrigation projects located upstream of Brownlee Reservoir. This proposed action is consistent with the terms of a 2004 water rights settlement in the Upper Snake River, which extends through 2034. The detailed description of the proposed action can be found in Chapter 2 of the Upper Snake River BA (USBR 2007), and is incorporated here by reference. The following is a short summary of the Upper Snake proposed action from *NOAA Fisheries' Executive Summary FCRPS and Upper Snake Biological Opinions* (NMFS 2007c):

"The proposed action on the Upper Snake River covers operations and maintenance of Reclamation's irrigation projects located in the Snake River Basin upstream from Brownlee Reservoir. Reclamation has described its proposal in 12 separate Federal actions and defined them according to projects located within the same drainage and operated in coordination with one another. Specifically, the proposed action for the Upper Snake River addresses water storage and release; diversion and pumping; power generation; and maintenance activities. It covers flow augmentation for salmon either through water rental pools and leasing, or acquiring rights to natural flows.

Contributing to the proposed action for the Upper Snake is the resolution of a long-standing dispute over water allocation in the Snake River Basin. Snake River flow is one of three components to the 2004 Nez Perce Water Rights Settlement addressing the use of water for flow augmentation from the Snake River above Brownlee Reservoir. This component of the settlement is the primary basis for the Reclamation's proposed action in the Upper Snake."

The two Federal actions (FCRPS and Upper Snake) described above are aggregated in this Comprehensive Analysis addendum and are referenced hereinafter as the Proposed Actions.

## III. GEOGRAPHIC AREA

The geographic area of this comprehensive analysis is consistent with the description of the FCRPS action area and the Upper Snake River project action area identified in the respective BAs.[1] Generally, the geographic scope addressed in this addendum to the Comprehensive Analysis encompasses the areas that are hydrologically influenced by the operation of the Upper Snake River projects and the FCRPS projects, including:

[1] A detailed description of the FCRPS action area is in the FCRPS BA - Section 1.3. A detailed description of the Upper Snake River action area is in the Upper Snake River BA in Section 2.2.

- The Snake River system and specified tributaries above Idaho Power Company's (IPC's) Hells Canyon Complex, the Snake River from the tailrace of Hells Canyon Dam (the last of IPC's three Hells Canyon Complex dams), and the Clearwater River below Dworshak Dam to the confluence with the Columbia River; and
- The Columbia River system from Libby and Hungry Horse dams in Montana, including specified tributaries down to and including the estuary and plume.

## IV. SPECIES AND CRITICAL HABITAT ADDRESSED

**Killer whales** *(Orcinus orca)*: The Southern Resident DPS of killer whales was listed as endangered under the Endangered Species Act on November 18, 2005 (NMFS 2005). Killer whales are the world's largest dolphins and the listed Southern Resident DPS overlaps in range in the northeastern Pacific Ocean with other whale populations classified as transient, resident, and offshore populations. The Southern Resident population consists of three pods designated J, K and L, each containing 24, 22 and 44 members respectively (Ford et al. 2000; Center for Whale Research 2006, unpublished data). These pods generally spend late spring, summer and fall in inland waterways of Washington State and British Columbia. They are also known to travel as far south as central California and as far north as the Queen Charlotte Islands. Winter and early spring movements are largely unknown for this DPS. There have been four sightings of Southern Resident DPS within the Columbia River plume (NMFS 2007d, Table 1).

Critical habitat for the Southern Resident DPS was designated under the Endangered Species Act on November 29, 2006 (NMFS 2006a). The critical habitat designation encompasses parts of Haro Strait and the waters around the San Juan Islands, the Strait of Juan de Fuca and all of Puget Sound. The designated critical habitat does not overlap with the area considered for this consultation, nor are there any discernible changes to the physical environment that occur there that could be correlated to the operations of the FCRPS or Upper Snake dams, or from FCRPS mitigation hatcheries; therefore the Proposed Actions will not affect critical habitat for the killer whale.

**Green sturgeon** *(Acipenser medirostris)*: Upon completion of a status review, NMFS determined that green sturgeon comprise two DPSs that qualify as species under ESA: 1) a northern DPS, consisting of populations in coastal systems from the Eel River, California northward, that was determined to not warrant listing; and 2) a southern DPS consisting of coastal and Central Valley populations south of the Eel River, with the only known spawning population in the Sacramento River (Adams et al. 2002). The southern distinct population segment (DPS) of green sturgeon was listed as threatened under the ESA by NMFS on April 7, 2006 (NMFS 2006b). Take prohibitions via section 4(d) of the ESA have not yet been promulgated, nor has critical habitat yet been designated for the southern DPS, although both actions are expected to occur in 2008. Green sturgeon are known to range in nearshore marine waters from Mexico to the Bering Sea, and are commonly observed in bays and estuaries along the west coast of North America, including the Columbia River (NMFS 2008).

# V. KILLER WHALES

## V.1. Status/Population Trend

In general, little information is available regarding the historical abundance of Southern Resident killer whales. Some evidence suggests that, until the mid- to late-1800s, the Southern Resident killer whale population may have numbered more than 200 animals (Krahn et al. 2002). This estimate was based, in part, on a recent genetic analysis of microsatellite DNA, which found that the genetic diversity of the Southern Resident population resembles that of the Northern Residents (Barrett-Lennard 2000, Barrett-Lennard and Ellis 2001), and concluded that the two populations were possibly once similar in size. Recent efforts to assess the killer whale population during the past century have been hindered by an absence of empirical information prior to 1974 (NMFS 2006c). For example, a report by Scheffer and Slipp (1948) is the only pre-1974 account of Southern Resident abundance in the area, and it merely noted that the species was "frequently seen" during the 1940s in the Strait of Juan de Fuca, northern Puget Sound, and off the coast of the Olympic Peninsula, with smaller numbers along Washington's outer coast. Olesiuk et al. (1990) estimated the Southern Resident population size in 1967 to be 96 animals. At about this time, marine mammals became popular attractions in zoos and marine parks, which increased the demand for interesting and exotic display animals. Between 1967 and 1973, it is estimated that 47 killer whales, mostly immature, were taken from the Southern Resident population for public display. The rapid removal of individual whales caused an immediate decline in numbers (Ford et al. 2000). By 1971, the level of removal decreased the population by about 30 percent, to approximately 67 whales (Olesiuk et al. 1990). In 1993, two decades after the live capture of killer whales ended, the three Southern Resident pods—J, K, and L—totaled 96 animals (Ford et al. 2000).

Over the past decade, the Southern Resident population has fluctuated in numbers. For example, the population appeared to experience a period of recovery by increasing to 99 whales in 1995, but then declined by 20 percent to 79 whales in 2001 (-3.3% per year) before another slight increase to 83 whales in 2003 (Ford et al. 2000; Carretta et al. 2004). Although the population estimate for 2006 is approximately 90 animals (+3.5% per year since 2001) (Center for Whale Research 2006), the decline in the 1990s, unstable population status, and population structure (e.g., few reproductive-age males and non-calving adult females) continue to be causes for concern. Moreover, it is unclear whether the recent increasing trend will continue, because these observations may represent an anomaly in the general pattern of survival or a longer-term shift in the survival pattern. Several individuals disappeared in the fall of 2006 and one new calf has been identified since the 2006 population estimate (NMFS 2007d).

There have been four documented sightings of Southern Resident killer whales off the coast of Oregon and Washington near the Columbia River, in 2005 and 2006. Two sightings were in March and two in October (NMFS 2008a).

## V.2 Key Limiting Factors for Killer Whales

As discussed in the Federal Register listing notice (NMFS 2005), three main human-caused factors that may continue to impede the recovery of this species have affected the Southern Resident killer whale population, including contaminants, vessel traffic, and reductions in prey availability. Each of these factors is discussed below.

Exposure to contaminants may result in harm to the species. The presence of high levels of persistent organic pollutants (POPs), such as PCBs and DDT, are documented in Southern Resident killer whales (Ross et al. 2000, Ylitalo et al. 2001, Herman et al. 2005). These and other chemical compounds have the ability to induce immune suppression, impair reproduction, and produce other adverse physiological effects, as observed in studies of other marine mammals. High levels of recently recognized contaminants that may have similar negative effects, such as PBDEs (flame retardants), have been documented in killer whales, and are also becoming more prevalent in the marine environment (Rayne et al. 2004). Although contaminants enter marine waters and sediments from numerous sources, these chemical compounds enter killer whales through their prey. Because of their long life span, position at the top of the food chain, and their blubber stores, killer whales are capable of accumulating high concentrations of contaminants.

Commercial shipping, whale watching, ferry operations, and recreational boat traffic have increased in recent decades. Several studies have linked vessels with short-term behavioral changes in Northern and Southern Resident killer whales (Kruse 1991; Williams et al. 2002a and 2002b; Foote et al. 2004). Although the potential impacts from vessels and the sounds they generate are poorly understood, these activities may affect foraging efficiency, communication, and/or energy expenditure through their physical presence, increased underwater sound level, or both. Collisions with vessels are another potential source of serious injury and mortality and have been recorded for both Southern and Northern Resident whales.

Salmon are assumed to be the primary prey species for Southern Residents. Most of the information concerning Southern Resident killer whale diet and consumption is derived from one study (Ford and Ellis 2005). (It is worth noting that the majority of the study samples were from the Northern Resident DPS, and only 14 % were from the Southern Resident DPS.) According to the study, killer whales are known to consume 22 species of fish, with salmon representing over 96% of the prey consumed during spring, summer and fall (winter consumption habits were not studied).

While Chinook salmon are identified as a distinct prey preference (NMFS 2006c), chum salmon also appear to be an important prey species for the Southern Resident DPS (NMFS 2007d). However, long-term abundance and population trend estimates are not available for Columbia River chum salmon, and estimates of recent abundance for the two lower river populations for which data are available show a combined mean of 756 spawners during the years 1996-2000 (NMFS 2007a). These data suggest that Columbia River chum salmon are not a significant portion of the prey base for killer whales.

Wild salmon populations have declined from numbers estimated to have occupied the Columbia River system in the late 1800s due to habitat degradation from development (e.g., agriculture, timber harvest, dam construction, and urban construction), harvest

practices, and past detrimental hatchery operations. Some historically productive populations are no longer large, whereas other runs may have increased in abundance through hatchery production. Historical sources of the Pacific salmon prey base for killer whales include Alaskan, Canadian, Puget Sound, Columbia River Basin and Central California rivers and streams. Specifically, declines in food availability from the Columbia and the California Central Valley were identified by NMFS as major sources for the decline in the Pacific salmon prey base of killer whales when killer whales were listed. Reductions in prey availability may force the whales to spend more time foraging, and could lead to reduced reproductive rates and higher mortality. However, the analysis in this addendum shows that the long-term trend in availability of prey from the Columbia River is positive (see "Effects of the Action" below).

### V.3 Effects of the Proposed Actions on Killer Whales

As discussed in the Federal Register listing notice (NMFS 2005), the three main human-caused threats to the Southern Resident killer whale population are contaminants, vessel traffic, and reductions in prey availability. Killer whales do not come in contact with any FCRPS or Upper Snake facilities during their life cycle. The nearest FCRPS facility is 140 miles from the Pacific Ocean (where killer whales live) and the nearest Upper Snake facility is over 600 miles from the Pacific Ocean.

**Contaminants.** While the operations of the FCRPS and the Upper Snake hydro dams may result in occasional minor introductions of contaminants into the Columbia River when there is an accidental spill of hazardous or regulated substances, this possibility is speculative, and the amount of these discharges, compared to other sources that enter the Columbia, is typically minor.

The FCRPS and Upper Snake dams themselves are unlikely sources of contaminants because they are made of inert concrete, and their only industrial application is hydro power. In the event of an accident, likely sources of contaminants would be from the dam's electrical facilities, most of which are located in upland areas, and from turbine units within the river channel.

Environmental spills, today, are rare occurrences. Under today's highly regulated environment, the action agencies are required to take precautions to minimize potential spills. Spill action plans are in place, and internal and external assessments of facilities are performed regularly to ensure environmental compliance standards are being met. When environmental contamination is discovered on FCRPS or Upper Snake property, the action agencies work to eliminate the hazard as soon as possible. Thus, it is unlikely that killer whales feeding on adult salmonids in the ocean would ingest significant amounts of contaminants contributed by FCRPS and Upper Snake hydrosystem operations or accidental leaks from associated electrical facilities.

**Vessel traffic.** One of the many authorized purposes of the FCRPS project is navigation. Many commercial and recreational vessels using the Columbia and Snake River navigation system are likely to transit the plume and ocean. These vessels include barges and deep draft ships for international commerce and are operated by independent parties. While these operations are facilitated by the operation of the FCRPS, they are not being conducted by the Action Agencies as part of the proposed actions.

The Proposed Actions would involve a limited number of research boats operating in the Columbia River plume. Any FCRPS mitigation research vessels would be well aware of and would strictly follow protocols regarding interactions with killer whales. The increase in risk (if any) for killer whale encounters with FCRPS research vessel traffic would be insignificant.

**Reductions in prey availability.** The question has been raised whether effects on salmonids related to the FCRPS and Upper Snake Proposed Actions result in fewer adult salmon available as prey for the Southern Resident killer whale population.

In evaluating the combined effects of the FCRPS and Upper Snake Projects on the listed Southern Resident killer whales, it is important to consider the following factors:

- First, salmon from the Columbia River constitute only one part of the killer whale prey base; other prey (even assuming all prey are salmon, which is not the case) would originate from Puget Sound streams, coastal streams in Washington, Oregon, and California, and the Sacramento-San Joaquin system. It is not known what portion of the killer whale prey base is composed of Columbia River salmon. The spring, summer and fall range of the Southern Resident killer whales includes the inland waterways of Puget Sound, the Strait of Juan de Fuca, and the Southern Georgia Strait, and the whales have been documented off the coast of central California and off the Queen Charlotte Islands (NMFS 2005). Their wide-ranging migratory patterns put them in the proximity of numerous other stocks of salmon.
- Second, the portion of the killer whale prey base that comes from the Columbia River includes both wild and hatchery produced salmon, both ESA-listed and not.
- Third, Columbia River salmon are affected by many factors in addition to the proposed actions. For example, Columbia River salmon have been, and continue to be, affected by increasing population growth throughout the basin; associated increased resource use, urbanization and associated increased losses of habitat; pollution; fishing; and a number of other factors (Lackey et al. 2006).

Finally, any effects of the proposed actions on juvenile salmon are removed both in time and in place from when and where these fish could *potentially* become killer whale prey. This is because the proposed actions affect juvenile salmon in the Columbia River; these same fish may or may not encounter listed killer whales *in the ocean one to three years after* having any contact with the FCRPS. Many of these fish spend one to three years in the ocean subjected to many factors not related to the proposed actions; others die from causes not related to the proposed actions. For example, ocean conditions are known to strongly affect adult salmon returns to the Columbia River, and therefore adult salmon available as killer whale prey.

Thus, considering the above, any potential effects of the proposed actions on listed killer whale prey are trophic and indirect; are far removed in both time and place from the action; represent an unknown portion of the killer whale prey base; and are intermingled with a host of other factors. These effects therefore seem insignificant or close to insignificant (i.e, largely immeasurable). For the sake of completeness, this document

includes further analyses of 1) the effects of the proposed actions on Columbia River juvenile salmon, which at maturity, form an unknown part of the killer whale prey base; 2) the effects of the hatchery program on salmon that might become killer whale prey; and 3) a comprehensive analysis of adult Chinook salmon returns to the Columbia River.

*Effects of the proposed actions on salmon*

Survival of juvenile salmon passing through the FCRPS has increased over the past many years because the system has been substantially modified specifically for salmon (Appendix A, USACOE et al. 2007). In spite of these substantial improvements, the proposed actions will continue to adversely affect juvenile salmon. Estimated mortalities are listed in Table 12.2 of the Draft FCRPS Biological Opinion (NMFS 2007a). We assume here that survival through the system is similar for hatchery-produced and wild fish. Note that many Snake River salmon and steelhead, including hatchery-produced salmon and steelhead, are transported under certain flow conditions, which improves their survival. Note also that Table 12.2 essentially identifies mortality from *all* sources as the fish move through the system: anything that previously affected the fish and resulted in mortality during migration, and mortality from other factors that occur at the same time and same place (such as the interstate highway and other roads that parallel the Columbia River, any non-federal diversions from the river, sources of pollution along the route that affect fish, losses or degradation of salmon habitat, and losses that would occur even in a natural unimpounded river). As discussed in the comprehensive analysis (USACOE et al. 2007), the proposed actions are expected to improve survival of juvenile salmon compared to current conditions due to improved hydro conditions, habitat actions, hatchery reform actions, and predator management.

*Inclusion of hatchery fish as part of the prey base*

Columbia River hatchery-produced salmon presumably also contribute to the Columbia River portion of the killer whale prey base. Hatcheries have resulted in significant numbers of juvenile salmon leaving the Columbia River for the ocean, some portion of which later become prey for listed Southern Resident killer whales. The production of hatchery coho and Chinook salmon from all Pacific Northwest hatcheries, both federal and non-federal, increased rapidly from 1900 to 1992, reaching a level of over 400 million Chinook smolts by the late 1980s (Figure 1) (Mahnken *et al.* 1996). Although the number of adult salmon ultimately resulting from the smolt production depends on ocean conditions, the steadily increasing hatchery production over the 92-year period is likely a highly beneficial contribution to the food supply of killer whales. There has been only a slight decrease in the number of Chinook salmon smolts produced by FCRPS Columbia River Basin hatcheries during the 2004-2007 period, while numbers of coho salmon and steelhead released have remained stable or increased (Table 1).

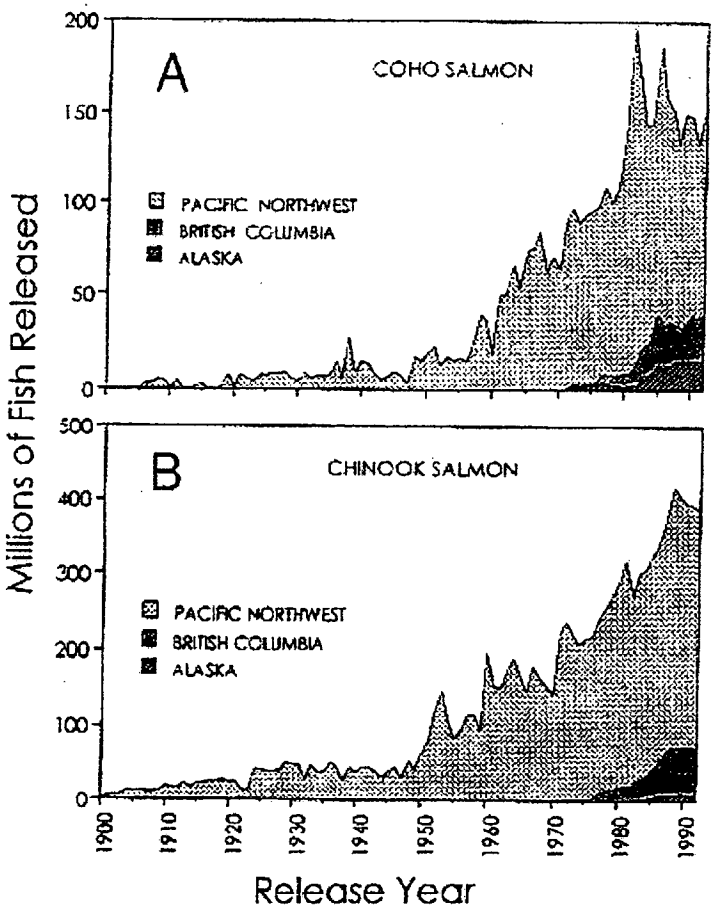


**Figure 1. Hatchery production of (A) coho salmon and (B) Chinook salmon juveniles from Pacific Northwest, British Columbia, and Alaskan hatcheries, 1900 – 1992 (Figure from Mahnken *et al.* 1996).**

| Species | 2004 | 2005 | 2006 | 2007 |
|---|---|---|---|---|
| Chinook Salmon | 28.3 | 33.4 | 29.7 | 29.0 |
| Coho Salmon | 5.1 | 3.5 | 4.0 | 3.3 |
| Steelhead | 6.8 | 8.1 | 8.4 | 8.5 |
| TOTAL | 40.2 | 45.0 | 42.1 | 40.8 |

**Table 1. Releases from FCRPS-funded hatcheries in the Columbia Basin from 2004-2007 (in millions). Data from UW DART website.**

Recent, current, and expected future hatchery reform efforts (undertaken at least in part as a result of the FCRPS consultations) should result in the production of hatchery smolts that are better adapted to local conditions with a corresponding increase in the rate of their survival to adulthood. This survival improvement has been described and estimated for certain listed Chinook salmon

populations in the BA/CA and Biological Opinion. (Appendix E of the Comprehensive Analysis (USACOE 2007) and Chapter 7.2.4 of the Supplemental Comprehensive Analysis (NMFS 2007e.) Therefore it is likely that hatchery reform efforts, by producing fitter fish, have compensated for recent Mitchell Act hatchery declines in production and will continue to do so.

*Comprehensive Analysis of Adult Chinook Salmon Returns*

This section analyzes the effects of past and ongoing human and natural factors on the Columbia River portion of the prey base of listed Southern Resident killer whales. It incorporates by reference and supplements the analysis and conclusions in the Comprehensive Analysis (FCRPS Action Agencies 2007) and NMFS' draft Biological Opinions regarding the future effects of the Action Agencies' Proposed Actions on listed salmonids in the Columbia River basin. Finally, it assesses the likely effects of the Proposed Actions on Southern Resident killer whale prey availability in the context of the environmental baseline and cumulative effects.

The environmental baseline includes: "the past and present impacts of all Federal, state, or private actions and other human activities in the action area, including the anticipated impacts of all proposed Federal projects in the action area that have undergone Section 7 consultation and the impacts of state and private actions that are contemporaneous with the consultation in progress" (50 C.F.R §402.02, "effects of the action"). The environmental baseline with respect to prey availability for listed killer whales is the number of adult fish available at times and places where the whales are thought to feed within the geographic area addressed by this comprehensive analysis.

Because the concern is the availability of killer whale prey originating in the Columbia River and its tributaries, and because the species that are thought to be the whales' preferred prey during their ocean migration are Chinook salmon (NMFS 2006c), we use the estimates developed by the fisheries managers (states and tribes) of the number of adult Chinook salmon that return each year to the mouth of the Columbia River. Included in these estimates are both naturally-produced and hatchery-produced spring, summer and fall runs.

While there has been significant year-to-year variation in the abundance of Chinook salmon returning to the Columbia River, abundance has remained more or less constant since dam counts began after the completion of Bonneville Dam in 1938 (see Figure 2). We also show killer whale abundance, which appears stable or increasing, on Figure 2. We would not expect to see any particular correlation between Chinook salmon abundances and killer whale abundances because of the many factors discussed under "Reductions in prey availability." As shown on the graph, little relationship is apparent.

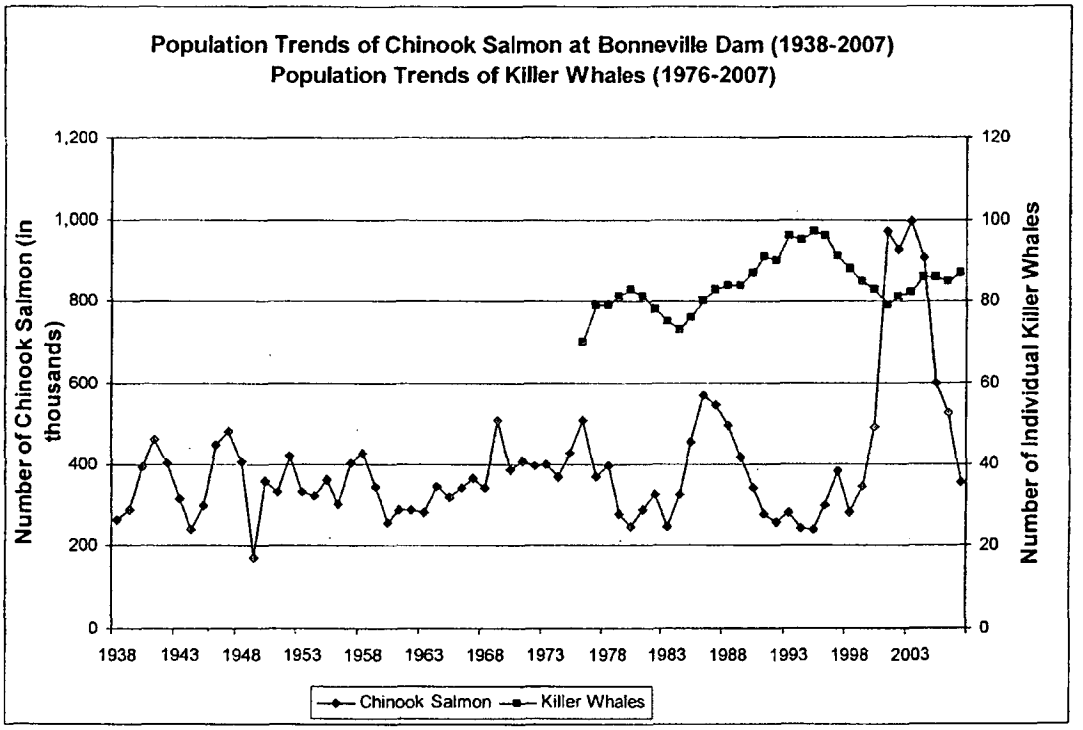


**Figure 2. Chinook Salmon Counts at Bonneville Dam (Adults and Jacks) and killer whale abundance**

Source for data in Figure 2: USCOE Northwest Division, Portland District (Chinook data); Center for Whale Research Website—http://www.whaleresearch.com/thecenter/research0001.html (killer whale data)

Depending on the time period and Chinook salmon stocks selected, abundance trends tend to fall within the range of a slight decline to a slight increase. For the sake of objectivity and consistency with the Comprehensive Analysis and draft Biological Opinions, we have chosen the same period used in those analyses for abundance trends of listed salmon and steelhead populations: 1980 to the most recent data available.

A trend analysis of total adult returns to the mouth of the Columbia River for the period 1980-2007 shows a slight increase in abundance (see Figure 3 below). Trend is calculated as the slope of the regression of the abundance index (log transformed) versus time. This method is identical to the method used in both the Comprehensive Analysis and draft Biological Opinion to estimate abundance trends for listed salmon and steelhead populations. It was taken from the draft report of the West Coast Salmon Biological Review Team (NOAA Fisheries BRT 2003)..

The exponentiated slope of the trendline in Figure 3 is 1.01, indicating a slight increase in total abundance over the time period. Note that there is large annual variability in salmon adult returns and this is mainly driven by ocean conditions.

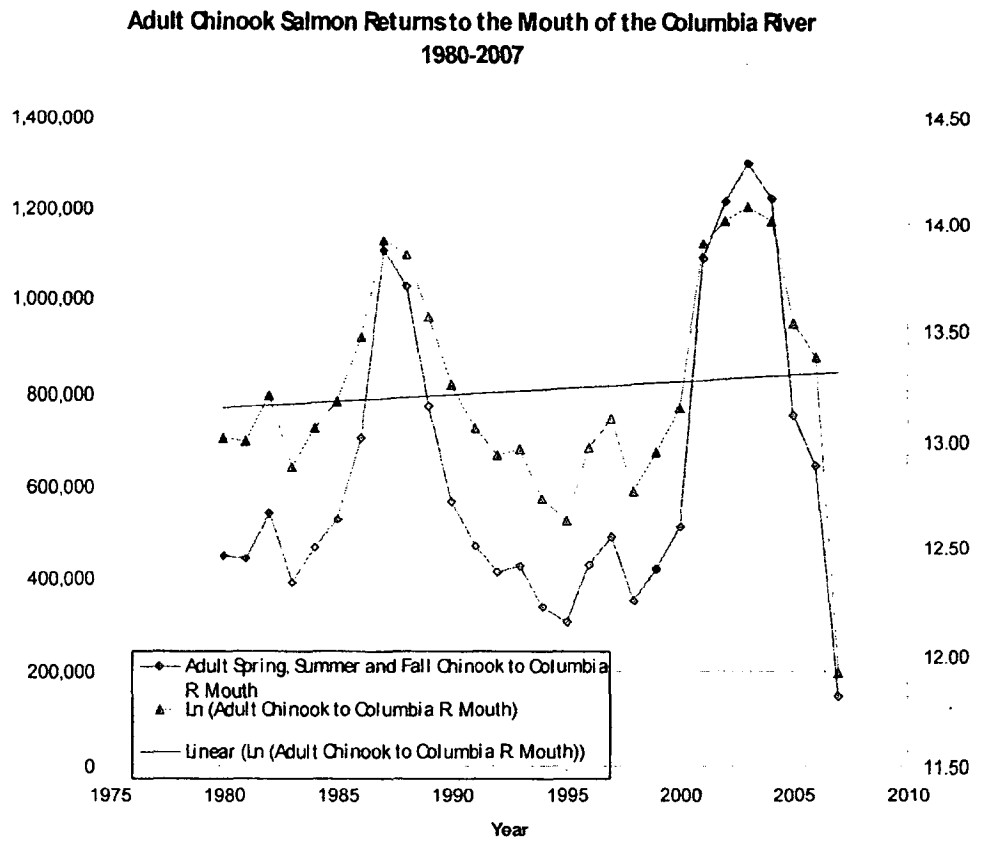


**Figure 3. Abundance Trend for Adult Chinook Salmon to the Mouth of the Columbia River***

*Note: The trend line is the one indicated as "Linear."

Source for data in Figure 3: 2008 Joint Staff Report: Stock Status and Fisheries for Spring Chinook, Summer Chinook, Sockeye, Steelhead, and Other Species, and Miscellaneous Regulations. *U.S. v. Oregon* Chinook Technical Advisory Committee.

NMFS' draft 2007 Biological Opinions conclude that all but two of the 34 extant populations that make up the listed Chinook salmon ESUs in the Interior Columbia River basin (above Bonneville Dam) will likely increase in abundance as a result of the Proposed Actions.[2] The BiOps assume that current levels of hatchery production will continue for the term of the BiOps, and they explicitly include future Action Agency funding of FCRPS mitigation hatcheries.

According to NMFS, "... it appears that the abundance of Washington, Oregon, and California Chinook and coho salmon increased significantly during the period of decline

[2] Regarding Chinook ESUs below Bonneville Dam, it was not possible to quantitatively assess expected future trends in abundance, though the significant levels of expected future hatchery production lend support to the view that overall abundance of fish from the Lower Columbia region will at least remain constant.

for Southern Resident killer whales between 1996 and 2001. Some studies have evaluated a potential time lag of one or two years between changes in salmon abundance and changes in Southern Resident survival (McClusky 2006). Even accounting for this potential lag time, the available information does not support a strong link between the trends in abundance of these particular salmon stocks and the abundance of Southern Resident killer whales." (NMFS 2007d). Generally, we note there is only a weak correlation between Southern Resident killer whale survival and Chinook salmon abundance in Washington and Oregon (Ford et al. 2005, NMFS 2007d).

Therefore, we conclude that the proposed FCRPS RPA's effect will be to increase the abundance of listed Chinook and other salmon originating above Bonneville Dam compared to their current status. This increased abundance, combined with the hatchery-related actions included in the draft FCRPS BiOp that will increase future fish survival, lead to the conclusion that prey abundance for killer whales should increase as a result of the Proposed Actions. As shown in the analysis above, current trends in Chinook salmon abundance at the mouth of the Columbia River are positive (trend >1.0). The Proposed Actions will benefit listed killer whales by increasing their prey base, an improvement over an already improving environmental baseline.

# VI. GREEN STURGEON

## VI.1. Status/Population Trend

Quality data on current population sizes for green sturgeon is non-existent, and data on population trends are lacking. Green sturgeon are the most marine-oriented of the North American sturgeon species. Juveniles of this species are able to enter estuarine waters after only one year in freshwater. During this time, they are believed to feed on benthic invertebrates, although little is known about rearing habitats and feeding requirements. Green sturgeon are known to range in nearshore marine waters from Mexico to the Bering Sea, and are commonly observed in bays and estuaries along the west coast of North America, including the Columbia River (NMFS 2008). The only known Southern DPS green sturgeon spawning locations are in the Sacramento River. Sturgeon are known to have strong homing capability which leads to high spawning-site fidelity. Observations of green sturgeon in the Columbia River are concentrated in the estuary but have been made as far upriver as Bonneville Dam. No evidence exists for spawning in this system (Rien et al. 2002). Information based primarily on fishery-dependent sampling suggests that green sturgeon occupy large estuaries only during the summer and early fall. Southern population DPS green sturgeon are known to occur in the Columbia River estuary from June until October. Tagging studies indicate that green sturgeon from all known spawning populations inhabit the Columbia estuary in summer, including a significant portion of green sturgeon from the southern DPS (Moser and Lindley 2006).

## VI.2. Key Limiting Factors for Green Sturgeon

As discussed in the Federal Register listing notice (NMFS 2006b), the principal factor in the decline of the Southern DPS is the reduction of the spawning area to a limited section of the Sacramento River. The potential for catastrophic events to affect such a limited spawning area increases the risk of the green sturgeon's extirpation. Insufficient freshwater flow rates in spawning areas, contaminants (e.g., pesticides), bycatch of green

sturgeon in fisheries, potential poaching (e.g., for caviar), entrainment of juveniles by water projects, influence of exotic species, small population size, impassable migration barriers, and elevated water temperatures in the spawning and rearing habitat likely also pose threats to this species (NMFS 2006b).

### VI.3. Effects of the Proposed Actions on Green Sturgeon

As discussed in the Federal Register listing notice for green sturgeon (NMFS 2006b), the principal factor in the decline of the Southern DPS is the reduction of the spawning area to a limited section of the Sacramento River. Because there is no evidence that green sturgeon have ever spawned in the Columbia River (Rien et al. 2002), which is the area considered for this consultation, effects on green sturgeon spawning areas are not considered. Many of the other threats listed in the notice are also limited to the spawning, juvenile rearing, and migration habitat in California, and would similarly not be factors in this consultation.

Bycatch of green sturgeon in fisheries and potential poaching are two activities that could affect green sturgeon in the area considered for this consultation. Until the green sturgeon was listed under the ESA in 2006, the states of Oregon and Washington conducted sport and commercial fisheries for green sturgeon. The range of harvest from 1960 to 2000 was approximately 200-6,000 annually. However, retention of green sturgeon in any fishery on the Columbia has been prohibited since 2006. Current incidental mortality of green sturgeon in commercial and sport fisheries that target white sturgeon (*A. transmontanus*) and Chinook salmon (*Oncorhynchus tshawytscha*) is estimated to be generally low and much reduced from previous years (NMFS 2006d). The FCRPS and Upper Snake actions do not include harvest and therefore don't contribute any direct fisheries-related effects to green sturgeon. This is a discountable effect.

The Action Agencies do not believe any adverse effects to green sturgeon are attributable to dam operations. Some green sturgeon apparently travel as far up the Columbia River as Bonneville Dam. While a navigation lock at the dam allows for unimpeded passage and sturgeon are sometimes seen in the fish ladders, there is no evidence that green sturgeon attempt to migrate above the dam.

It is possible that green sturgeon could be affected by legacy contaminants in the river that move downstream during hydrosystem operations. However, as stated for the killer whale, while the operations of the FCRPS and the Upper Snake hydro dams may result in occasional minor introductions of contaminants into the Columbia River, precautions and regulations are followed to minimize such releases and therefore this is most likely an insignificant effect. Also, the majority of the green sturgeon concentrate in the lower estuary, 100 miles downstream of the lowermost Columbia River dam. Green sturgeon do not come in contact with any Upper Snake project facilities during their life cycle.

Because the green sturgeon are bottom (benthic) feeders, they are not known to rely on salmonids as a prey base. Thus, the issue of dam operations reducing green sturgeon's prey base does not arise as a potential adverse effect on green sturgeon.

Because the majority of green sturgeon are found in the lower 40 miles of the Columbia River, the dam operations may cause some indirect effects on green sturgeon habitat in

the lower river. However, given the opportunistic nature of the green sturgeon occupation in the lower river, and the lack of reference in the literature to any known disruption of behavior patterns, such as breeding, foraging, or other behavior, the Action Agencies believe dam operations would not adversely affect the green sturgeon. Moreover, the proposed RPA includes numerous habitat actions that are likely to improve habitat conditions in the estuary in locations that might be used by green sturgeon.

FCRPS hatchery operations are not likely to adversely affect green sturgeon, since no major FCRPS hatcheries operate in the lower river. BPA does fund the Select Area Fisheries Evaluation (SAFE) project (BPA project #199306000), involving net-pen rearing of juvenile salmon at four sites in the Columbia estuary: Youngs Bay, Tongue Point/South Channel, Blind Slough/Knappa Slough, and Deep River. Approximately 4 million coho, spring, and fall Chinook salmon hatchery juveniles are reared for about 6 months (November-April) in the SAFE net pens and then released as smolts.[3] The net pens used to hold the juvenile salmon may impact benthic invertebrate populations through deposition of organic wastes on the river bed under the pens (Nash 2001). Benthic macroinvertebrates are a potential food item for green sturgeon. According to the 2007-09 SAFE project proposal (FY 2007-2009 F&W Program Project Solicitation Section 10 Narrative, Project ID: 199306000, Title: Select Area Fisheries Enhancement Project), a program to monitor benthic macroinvertebrates under the net pens was begun in 1994. The project sponsors report the overall impact has been only a minor change in macroinvertebrate populations during the rearing period (November-April), with returns to baseline levels by the beginning of the next rearing season. Based on this information, plus the relatively miniscule area in the Columbia estuary riverbed occupied by the net pens, the operation of the net pens is extremely unlikely to adversely affect green sturgeon (i.e., this is an insignificant effect).

## VII. Conclusions

**Killer whale:** Based on the analysis in this addendum to the CA, the Action Agencies have determined that the Proposed Actions may affect, but are not likely to adversely affect, the Southern Resident DPS of killer whales.

**Green sturgeon:** Based on the analysis in this addendum, the Action Agencies have determined that the FCRPS and Upper Snake dam operations, and operations of the SAFE net rearing project may affect, but are not likely to adversely affect, the Southern DPS of green sturgeon.

## VIII. References

Adams, P.B., C.B. Grimes, J.E. Hightower, S.T. Lindley, and M.L. Moser. 2002. Status Review for the North American green sturgeon. NOAA, National Marine Fisheries Service, Southwest Fisheries Science Center, Santa Cruz, CA. 49 pp.

[3] They provide a terminal hatchery fishery that reduces fishing pressure on listed anadromous salmonid stocks in the estuary. This project is an FCRPS mitigation action and is part of the RPA for the FCRPS consultation.

Barrett-Lennard, L.G. 2000. Population structure and mating patterns of killer whales as revealed by DNA analysis, Ph.D. Thesis, University of British Columbia, Vancouver, British Columbia.

Barrett-Lennard, L.G. and G.M. Ellis. 2001. Population structure and genetic variability in northeastern Pacific killer whales: towards an assessment of population viability. Research Document 2001/065, Fisheries and Oceans Canada, Nanaimo, British Columbia.

Carretta, J.V., K.A. Forney, M.M. Muto, J.Barlow, J.Baker, and M. Lowry. 2004. U.S. Pacific marine mammal stock assessments: 2003. NOAA Technical Memorandum NMFS-SWFSC-358, U.S. Department of Commerce, San Diego, California.

Center for Whale Research. 2006. http://www.whaleresearch.com/thecenter/research.html

Foote, A.D., R.W. Osborne, and A.R. Hoelzel. 2004. Whale-call response to masking boat noise. Nature 428-910.

Ford, J.K.B. and G.M. Ellis. 2005. Prey selection and food sharing by fish-eating 'resident' killer whales (Orcinus orca) in British Columbia. Fisheries and Oceans Canada, Canadian Science Advisory Secretariat 2005/041.

Ford, J.K.B., G.M. Ellis and K.C. Balcomb. 2000. Killer whales: the natural history and genealogy of Orcinus orca in British Columbia and Washington State. 2nd ed. UBC Press, Vancouver, British Columbia.

Ford, J.K.B., G.M. Ellis, and P.F. Olesiuk. 2005. Linking prey and population dynamics: did food limitation cause recent declines of 'resident' killer whales (*Orcinus orca*) in British Columbia? Fisheries and Oceans Canada, Canadian Science Advisory Secretariat 2005/042.

Good, T.P., R.S. Waples and P. Adams (editors). 2005. Updated status of federally listed ESUs of West Coast salmon and steelhead. U.S. Dept. Commer. NOAA Tech. Memo. NMFS-NWFSC-66, 598 pp.

Heard, W. R., E. Shevlyakov, O. V. Zikunova, and R. E. McNicol. 2007. Chinook salmon – trends in abundance and biological characteristics. North Pacific Anadromous Fish Commission Bulletin No. 4: 77-91.

Herman, D. P., D. G. Burrows, P. R. Wade, J. W. Durban, C. O. Matkin, R. G. LeDuc, L. G. Barrett-Lennard, and M. M. Krahn. 2005. Feeding ecology of eastern North Pacific killer whales (Orcinus orca) from fatty acid, stable isotope, and organochlorine analyses of blubber biopsies. Marine Ecology Progress Series 302:275-291.

Kope, R. and T. Wainwright. 1998. Trends in the status of Pacific salmon populations Washington, Oregon, California, and Idaho. North Pacific Anadromous Fish Commission Bulletin 1:1-12.

Krahn, M. M., P. R. Wade, S. T. Kalinowski, M. E. Dahlheim, B. L. Taylor, M. B. Hanson, G. M. Ylitalo, R. P. Angliss, J. E. Stein, and R. S. Waples. 2002. Status review of southern resident killer whales (Orcinus orca) under the Endangered

Species Act. U.S. Department of Commerce, NOAA Technical Memorandum NMFS-NWFSC-54, 133 pp.

Kruse, S. 1991. The interactions between killer whales and boats in Johnstone Strait, B.C. Pages 149-159 in K. Pryor and K.S. Norris, editors. Dolphin societies: discoveries and puzzles. University of California Press, Berkeley, California.

Lackey, R.T. 2003. Pacific Northwest salmon: forecasting their status in 2100. Reviews in Fisheries Science 11:35-88.

Lackey, R.T., D.H. Lach and S.L. Duncan (eds). 2006. Salmon 2100: The future of Wild Pacific Salmon. Amer. Fish. Soc., Bethesda, MD.

LCREP (Lower Columbia River Estuary Partnership). 2007. Lower Columbia River and Estuary Ecosystem Monitoring: Water Quality and Salmon Sampling Report.

Mahnken, C., G. Ruggerone, W. Waknitz, and T. Flagg. 1996. A historical perspective on salmonid production from Pacific Rim hatcheries. North Pacific Anadromous Fish Commission Bulletin No. 1: 38-53.

McCluskey, S. M. 2006. Space use patterns and population trends of Southern Resident Killer Whales (Orcinus orca) in relation to distribution and abundance of Pacific salmon (Oncorhynchus spp.) in the inland marine waters of Washington State and British Columbia. M.S. Thesis, University of Washington, Seattle, Washington.

Moser, M. L. and S. T. Lindley. 2006. Use of Washington Estuaries by Sub Adult and Adult Green Sturgeon. Environmental Biology of Fishes, DOI 10:1007/s10641-006-9028-1.

Moyle, P. B. 2001. Inland Fishes of California, 2nd edition. University of California Press, Berkeley. 517 pp.

Nash, C. E. (editor). 2001. The net-pen salmon farming industry in the Pacific Northwest. U.S. Dept. Commer., NOAA Tech Memo. NMFS-NWFSC-49, 125 pp.

Nehlsen, W. 1997. Pacific salmon status and trends – a coastwide perspective. Pages 21-50 in D.J. Stouder, P.A. Bisson, and R.J. Naiman, editors. Pacific salmon & their ecosystems: status and future options. Chapman & Hall, New York, New York.

NMFS. 2005. Endangered and Threatened Wildlife and Plants: Endangered Status for Southern Resident Killer Whales, Final Rule, Federal Register, 70 FR 69903.

NMFS. 2006a. Endangered and Threatened Species: Designation of Critical Habitat for Southern Resident Killer Whale, Final Rule, Federal Register, 71 FR 69054.

NMFS. 2006b. Endangered and Threatened Wildlife and Plants: Threatened Status for Southern Distinct Population Segment of North American Green Sturgeon, Final Rule, Federal Register, 71 FR 17757.

NMFS. 2006c. Proposed Recovery Plan for Southern Resident killer whales (*Orcinus orca*), National Marine Fisheries Service, Northwest Region, Seattle, Washington. 219 pp.

NMFS. 2006d. Supplemental Biological Opinion Reinitiating Consultation on the May 9, 2005, Biological Opinion on the effects of U.S. v. Oregon Fisheries Managed

Under the Interim Management Agreement Fisheries on Columbia River Salmonid Species Listed Under the Endangered Species Act to Consider the Effects on the Newly Listed Lower Columbia River Coho Salmon Evolutionarily Significant Unit and Green Sturgeon From the Southern Distinct Population Segment." NOAA's National Marine Fisheries Service, Northwest Region. NOAA Fisheries Log Number: F/NWR/2006/04258. October 11, 2006, 76 pp.

NMFS. 2007a. Endangered Species Act (ESA) Section 7 Consultation – Biological Opinion Remand Draft. Consultation on Remand for Operation of the Federal Columbia River Power System, 11 Bureau of Reclamation Projects in the Columbia Basin and ESA Section 10(a)(1)(A) Permit for Juvenile Fish Transportation Program (Revised and reissued pursuant to court order, NWF v. NMFS, Civ. No. CV 01-640-RE (D. Oregon)). NOAA's National Marine Fisheries Service, Northwest Region. NOAA Fisheries Log Number: F/NWR/2005/05883. October 30, 2007, 729 pp.

NMFS. 2007b. Endangered Species Act Section 7(a)(2) Consultation - Draft Biological Opinion and Magnuson-Stevens Fishery Conservation and Management Act Consultation (Revised and reissued pursuant to court order, American Rivers v. NOAA Fisheries, CV 04-0061-RE (D. Oregon)). Consultation for the Operation and Maintenance of 10 U.S. Bureau of Reclamation Projects and 2 Related Actions in the Upper Snake River Basin above Brownlee Reservoir. National Marine Fisheries Service, Northwest Region. NMFS Log Number: F/NWR/2006/07518. October 30, 2007, 566 pp.

NMFS. 2007c. Executive Summary for the Draft FCRPS and Upper Snake River Biological Opinions. October 30, 2007.

NMFS. 2007d. Endangered Species Act (ESA) Section 7 Consultation – Biological Opinion. Effects of the 2007 Pacific Coast Salmon Plan fisheries on the Southern Resident Killer Whale Distinct Population Segment (*Orcinus orca*) and their Critical Habitat. NMFS Tracking Number: F/NWR/2007/02505. May 3, 2007. 68 pp.

NMFS (National Marine Fisheries Service). 2007e. Supplemental comprehensive analysis of the Federal Columbia River Power System and mainstem effects of USBR Upper Snake and other tributary actions. Portland, Oregon. October 31.

NMFS. 2008. Biological Opinion on the Re-issuance of Regional General Permit 3, authorizing 23 maintenance activities in Suisun Marsh, Solano County, California. National Marine Fisheries Service, Southwest Region, 2007/07657.

NMFS. 2008a. Recovery Plan for Southern Resident Killer Whales (*Orcinus orca*). Prepared by National Marine Fisheries Service Northwest Regional Office. January 17, 2008.

ODFW and WDFW. 2000. Joint Staff Report Concerning the 2000 In-river Commercial Harvest of Columbia River Fall Chinook Salmon, Summer Steelhead, Coho Salmon, and Sturgeon, Joint Columbia River Management Staff ,Oregon Department of Fish and Wildlife, Washington Department of Fish and Wildlife. July 13, 2000.

ODFW and WDFW. 2000. Status Report. Columbia River Fish Runs and Fisheries, 1938-1999. Oregon Department of Fish and Wildlife, Washington Department of Fish and Wildlife. 309 pp.

ODFW and WDFW, 2006, 2007 Joint Staff Report: Stock Status and Fisheries for Sturgeon and Smelt. Oregon Department of Fish and Wildlife, Washington Department of Fish and Wildlife. 41 pp.

Olesiuk, P.F., M.A. Bigg, and G.M. Ellis. 1990. Life history and population dynamics of resident killer whales (Orcinus orca) in the coastal waters of British Columbia and Washington State. Rep. Int. Whal. Commn. (special issue) 12: 209-244.

Osborne, R.W. 1999. A historical ecology of Salish Sea 'resident' killer whales (*Orcinus orca*): with implications for management. Ph.D. thesis, University of Victoria, Victoria, British Columbia.

PFMC. 2007. Review of 2006 Ocean Salmon Fisheries. (Document prepared for the Council and its advisory entities.) Pacific Fisheries Management Council, 7700 NE Ambassador Place, Suite 200, Portland, Oregon 97220-1384.

Rayne, S., M. G. Ikonomou, P. S. Ross, G. M. Ellis, and L. G. Barrett-Lennard. 2004. PBDEs, PBBs, and PCNs in three communities of free-ranging killer whales (Orcinus orca) from the northeastern Pacific Ocean. Environmental Science and Technology 38:4293-4299.

Riddell, B.E. 1993. Spatial organization of Pacific salmon: what to conserve? Pages 23-41 in J.G. Cloud and G.H. Thorgaard, editors. Genetic conservation of salmonid fishes. Plenum Press, New York, New York.

Rien T., R. Farr and J. North. 2002. Green sturgeon population characteristics in Oregon. Oregon Department of Fish and Wildlife, Sport Fish Restoration Project F-178-R, Portland.

Ross, P. S., G. M. Ellis, M. G. Ikonomou, L. G. Barrett-Lennard, and R. F. Addison. 2000. High PCB concentrations in free-ranging Pacific killer whales, *Orcinus orca*: effects of age, sex and dietary preference. Marine Pollution Bulletin 40:504-515.

Scheffer, V.B. and J.W. Slipp. 1948. The whales and dolphins of Washington State with a key to the cetaceans of the west coast of North America. American Midland Naturalist 39: 257-337.

Scheuerell, M. and J. Williams. 2005. Forecasting climate-induced changes in the survival of Snake River spring/summer Chinook salmon (*Oncorhynchus tshawytscha*). Fisheries and Oceanography, 14(6): 448-457. NOAA Fisheries, Northwest Fisheries Science Center.

Schoonmaker, P.K., T. Gresh, J. Lichatowich, and H.D. Radtke. 2003. Past and present salmon abundance: bioregional estimates for key life history stages. Pages 33-40 in J.G. Stockner, editor. 65 Nutrients in salmonid ecosystems: sustaining production and biodiversity. American Fisheries Society, Symposium 34, Bethesda, Maryland.

Slaney, T.L., K.D. Hyatt, T.G. Northcote, and R.J. Fielden. 1996. Status of anadromous salmon and trout in British Columbia and Yukon. Fisheries 21(10):20-35.

USACOE, BPA, and USBR. 2007. Biological Assessment for Effects of Federal Columbia River Power System and Mainstem Effects of Other Tributary Actions on Anadromous Salmonid Species Listed Under the Endangered Species Act. U.S.

Army Corps of Engineers, Bonneville Power Administration, and U.S. Bureau of Reclamation. August 2007, 181 pp.

USBR. 2004. Biological Assessment for Bureau of Reclamation Operations and Maintenance in the Snake River Basin Above Brownlee Reservoir. U.S. Department of the Interior, Bureau of Reclamation, Pacific Northwest Region, Snake River Area. November 2004, 436 pp.

USBR. 2007. Biological Assessment for Bureau of Reclamation Operations and Maintenance in the Snake River Basin Above Brownlee Reservoir. U.S. Department of the Interior, Bureau of Reclamation, Pacific Northwest Region, Snake River Area. August 2007, 176 pp.

Weitkamp, L. A., T. C. Wainwright, G. J. Bryant, G. B. Milner, D. J. Teel, R. G. Kope, and R. S. Waples. 1995. Status review of coho salmon from Washington, Oregon, and California. NOAA Technical Memorandum NMFS-NWFSC-24, Department of Commerce, Seattle, Washington.

Wertheimer, A.C. 1997. Status of Alaska salmon. Pages 179-197 in D.J. Stouder, P.A. Bisson, and R.J. Naiman, editors. Pacific salmon & their ecosystems: status and future options. Chapman & Hall, New York, New York.

Williams, R., A.W. Trites, and D.E. Bain. 2002a. Behavioural responses of killer whales (Orcinus orca) to whale-watching boats: opportunistic observations and experimental approaches. Journal of Zoology (London) 256:255-270.

Williams, R., D.E. Bain, J.K.B. Ford, and A.W. Trites. 2002b. Behavioural responses of male killer whales to a 'leapfrogging' vessel. Journal of Cetacean Research and Management 4:305-310.

Ylitalo, G. M., C. O. Matkin, J. Buzitis, M. M. Krahn, L. L. Jones, T. Rowles, and J. E. Stein. 2001. Influence of life-history parameters on organochlorine concentrations in free-ranging killer whales (Orcinus orca) from Prince William Sound, AK. Science of the Total Environment 281:183-203.

Yoshiyama, R.M., F.W. Fisher, and P.B. Moyle. 1998. Historical abundance and decline of Chinook salmon in the Central Valley region of California. North American Journal of Fisheries Management 18:487-521.