Appendix A. ESU Descriptions

A-1 Snake River Spring/Summer Chinook Salmon

Geographic Boundaries and Spatial Distribution

The location, geology, and climate of the Snake River region create a unique aquatic ecosystem for chinook salmon. Spring- and/or summer-run chinook salmon are found in five principal subbasins of the Snake River (CBFWA 1990). Of these, the Grande Ronde and Salmon rivers are large, complex systems composed of several smaller tributaries that are further composed of many small streams. In contrast, the Tucannon and Imnaha rivers are small systems in which the majority of salmon production is in the main river itself. In addition to the five major subbasins, three small streams (Asotin, Granite, and Sheep creeks) that enter the Snake River between Lower Granite and Hells Canyon dams provide small spawning and rearing areas (CBFWA 1990). Although there are some indications that more than one ESU may exist within the Snake River basin, the data presently available are not sufficient to clearly demonstrate the existence of multiple ESUs or to define their boundaries. However, because of compelling genetic and life-history evidence that fall chinook salmon are distinct from other chinook salmon in the Snake River, they are considered to be a separate ESU.

Historical Information

Historically, spring and/or summer chinook salmon spawned in virtually all accessible and suitable habitat in the Snake River system (Evermann 1896; Fulton 1968). During the late 1800s, the Snake River produced a substantial fraction of all Columbia River basin spring and summer chinook salmon, with total production probably in excess of 1.5 million during some years. However, as evidenced by adult counts at dams, spring and summer chinook salmon have declined considerably since the 1960s (Corps 1989).

Life History

In the Snake River, spring and summer chinook share key life history traits. Both are stream-type fish, with juveniles that migrate swiftly to sea as yearling smolts. Depending primarily on location within the basin (and not on run-type), adults tend to return after either 2 or 3 years in the ocean. Both spawn and rear in small, high elevation streams (Chapman et al. 1991), although where the two forms co-exist, spring-run chinook spawn earlier and at higher elevations than summer-run chinook.

Habitat and Hydrology

Even prior to development of mainstem dams, habitat was lost or severely damaged in many small tributaries by construction and operation of irrigation dams and diversions, inundation of spawning areas by impoundments, and siltation and pollution from sewage, farming, logging, and mining (Fulton 1968). More recently, the construction of hydroelectric and water storage dams without adequate provisions for adult and juvenile passage in the upper Snake River has precluded the use of all spawning areas upstream from Hells Canyon Dam.

Hatchery Influence

There is a long history of human efforts to enhance production of chinook salmon in the Snake River Basin through supplementation and stock transfers. The evidence is mixed as to whether these efforts have altered the genetic makeup of indigenous populations. Straying rates appear to be very low.

A-2 Snake River Fall Chinook Salmon

Geographic Boundaries and Spatial Distribution

The Snake River basin drains an area of approximately 267,000 km, and incorporates a range of vegetative life zones, climatic regions, and geological formations, including the deepest canyon (Hells Canyon) in North America. The ESU includes the mainstem river and all tributaries, from its confluence with the Columbia River up to the Hells Canyon complex. Because genetic analyses indicate that fall-run chinook salmon in the Snake River are very distinct from spring/summer-run in the Snake basin (Waples et al. 1991), SR fall chinook salmon are considered separately from the other two forms. Moreover, they are considered separately from those assigned to the Upper Columbia River summer- and fall-run ESU because of considerable differences in habitat characteristics and adult ocean distribution and less definitive, but still significant genetic differences. However, there is some concern that recent introgression from Columbia River hatchery strays is causing the Snake River population to lose the qualities that made it "distinct" for ESA purposes.

Historical Information

Snake River fall chinook salmon remained relatively stable at high levels of abundance through the first part of this century, but declined substantially thereafter. Although historical abundance of fall chinook salmon in the Snake River is difficult to estimate, adult returns appear to have declined by about three orders of magnitude since the 1940s, and perhaps by another order of magnitude from pristine levels.

Life History

Fall chinook salmon in this ESU are ocean-type. Adults return to the Snake River at ages 2 through 5, with age 4 most common at spawning (Chapman et al. 1991). Spawning, which takes place in late fall, occurs in the mainstem and in the lower parts of major tributaries (NWPPC 1989; Bugert et al. 1990). Juvenile fall chinook salmon move seaward slowly as subyearlings, typically within several weeks of emergence (Chapman et al. 1991). Coded wire-tag data indicate that Snake River fall chinook have a far ranging oceanic distribution, with a significant proportion (about 20%) taken in Alaska and Canada, and in recent years 97% off Washington, Oregon, and California (Pacific Salmon Commission, Chinook Technical Committee Model 2000).

Habitat and Hydrology

Following hydropower development, the most productive areas of the Snake River Basin are now inaccessible or inundated. Currently, there are twelve dams on the mainstem Snake River. This has substantially reduced the distribution and abundance of fall chinook salmon (Irving and Bjornn 1981a).

Hatchery Influence

The Snake River has contained hatchery-reared fall chinook salmon since 1981 (Busack 1991b). However, artificial propagation has been a relatively recent enterprise, so cumulative genetic changes associated with artificial propagation may be limited. Wild fish are also incorporated into the brood stock each year, which should reduce divergence from the wild population. Release of subyearling fish may also help to minimize the differences in mortality patterns between hatchery and wild populations that can lead to genetic change (Waples in press).

Other

Some Snake River fall chinook historically migrated over 1,500 km from the ocean; although the Snake River population is currently restricted to habitat in the lower river, genes associated with the more lengthy migration may still reside in the population. Because longer freshwater migrations in chinook salmon tend to be associated with more extensive oceanic migrations (Healey 1983), maintaining populations occupying habitat well inland may be important in maintaining diversity in the marine ecosystem as well.

A-3 Upper Columbia River Spring-run Chinook Salmon

Geographic Boundaries and Spatial Distribution

This ESU includes spring-run chinook populations found in Columbia River tributaries between Rock Island and Chief Joseph dams, notably the Wenatchee, Entiat, and Methow river basins. These populations are genetically and ecologically separated from the summer- and fall-run populations that exist in the lower parts of many of the same river systems (Myers et al. 1998). Although fish in this ESU are genetically similar to spring chinook in adjacent ESUs (i.e., Mid-Columbia and Snake), they are distinguished on the basis of ecological differences in spawning and rearing habitat preferences. For example, spring-run chinook in upper Columbia tributaries spawn at lower elevations (500-1,000 m) than in the Snake and John Day river systems.

Historical Information

The upper Columbia River populations were intermixed during the Grand Coulee Fish Maintenance Project (1939 through 1943), resulting in loss of genetic diversity between populations in the ESU. This homogenization remains an important feature of the ESU. Fish abundance has followed a downward trend both recently and over the long term. At least six former populations from this ESU are now extinct, and nearly all extant populations have fewer than 100 wild spawners.

Life History (Including Ocean)

Upper Columbia spring chinook are considered stream type, with smolts migrating as yearlings. The majority of stream-type fish mature at 4 years of age. Very few coded-wire tags are recovered in the ocean fisheries, suggesting that these fish move quickly out of the North Central Pacific and do not migrate along the coast.

Habitat and Hydrology

Salmon in this ESU must pass up to nine Federal and private dams and Chief Joseph Dam prevents access to historical spawning grounds farther upstream. Degradation of remaining spawning and rearing habitat continues to be a major concern. These effects are largely associated with urbanization, irrigation projects, and livestock grazing along riparian corridors. Overall harvest rates are low for this ESU, currently <10% (ODFW and WDFW 1995).

Hatchery Influence

Spring -run chinook salmon from the Carson National Fish Hatchery (a large composite, non-native stock) were introduced into, and have been released from, a number of local hatcheries (Leavenworth, Entiat, and Winthrop National Fish Hatcheries [NFH]). There is little evidence that these hatchery fish stray into wild areas or hybridize with naturally spawning populations.

A-4 Upper Willamette River Chinook Salmon

Geographic Boundaries and Spatial Distribution

The Upper Willamette River Chinook ESU includes native spring-run populations above Willamette Falls and in the Clackamas River, and historically included sizable numbers of spawning salmon in the Santiam River, the middle fork of the Willamette River, and the McKenzie River as well as smaller numbers in the Molalla River, Calapooia River, and Albiqua Creek. Although the total number of fish returning to the Willamette has been relatively high (24,000), currently about 4,000 fish spawn naturally in the ESU, two-thirds of which are of hatchery origin. The McKenzie River supports the only remaining naturally reproducing population in this ESU.

Historical Information

There are no direct estimates of the size of the chinook salmon runs in the Willamette River Basin prior to the 1940s. McKernan and Mattson (1950) present anecdotal information that the native American fishery at the Willamette Falls may have yielded 2,000,000 lbs. (908,000 kgs) of salmon (454,000 fish @ 20 lbs. [9.08 kgs]). based on egg collections at salmon hatcheries, Mattson (1948) estimated that the spring chinook salmon run in the 1920s may have been 5 times the existing run size of 55,000 fish (in 1947) or 275,000 fish. Additionally, much of the early historical information on salmon runs in the Upper Willamette River Basin come from the operation reports from by state and federal hatcheries.

Life History

Fish in this ESU are distinct from adjacent ESUs in their life history and marine distribution. Willamette River chinook salmon have an ocean-type life history, historically migrating to the ocean during their first autumn. Coded wire tag recoveries indicate that these fish travel to marine waters of British Columbia and Alaska. However, a higher proportion of Willamette fish are recovered in Alaskan waters than fish from the Lower Columbia ESU. Upper Willamette River chinook mature in their fourth or fifth years. Historically, 5-year-old fish dominated the spawning migration runs, but in recent years, the majority of fish have matured at age 4. The timing of the spawning migration has been limited by Willamette Falls. High flows in the spring allowed access to the Upper Willamette basin, whereas low flows in the summer and autumn prevented later migrating fish from ascending the falls. This may have served as an isolating mechanism, separating this ESU from other nearby ESUs.

Habitat and Hydrology

Human activities have had enormous impacts on the salmonid populations in the Willamette drainage. First, the Willamette River, once a highly braided river system, has been dramatically simplified through channelization, dredging and other activities which have reduced available rearing habitat (i.e., stream shoreline) by as much as 75%. In addition, the construction of 37 dams throughout the basin has blocked access to over 700 kilometers of stream and river spawning habitat. These dams also alter the temperature regime of the Willamette and its tributaries, affecting the timing of development of naturally-spawned eggs and fry. Water quality is also affected by development and other economic activities. Agricultural and urban uses on the valley floor as well as timber harvest in the Cascade and Coast ranges contribute to increased erosion and sediment load in Willamette basin streams and rivers. Finally, since at least the 1920s, the lower Willamette has suffered from municipal and industrial pollution.

Hatchery Influence

Hatchery production in the basin began in the late nineteenth century. Eggs were transported throughout the basin, resulting in current populations that are relatively genetically homogeneous (although still distinct from surrounding ESUs). Hatchery production continues in the Willamette, with an average of 8.4 million smolts and fingerlings released each year into main river or its tributaries between 1975 and 1994. Hatcheries are currently responsible for the vast majority (90% of escapement) of production in the basin.

Other

Harvest on this ESU is relatively high both in the ocean and in-river. The total in-river harvest below the falls from 1991 through 1995 averaged 33% and has been much higher in the past. Ocean harvest was estimated to be 16% for the period 1982 through 1989. The ODFW (1998) provided information indicating that total (marine and freshwater) harvest rates on upper Willamette River spring run stocks have been reduced considerably for the 1991 through 1993 brood years to an average 21%.

A-5 Lower Columbia River Chinook Salmon

Geographic Boundaries and Spatial Distribution

The Lower Columbia River ESU is characterized by numerous short and medium-length rivers that drain the coast ranges and the west slope of the Cascade mountains. This ESU includes all native populations from the mouth of the Columbia River to the crest of the Cascade Range, excluding populations above Willamette Falls. The former location of Celilo Falls (drowned by The Dalles reservoir in 1960) is the eastern boundary for this ESU. "Stream-type" spring-run chinook salmon found in the Klickitat River or the introduced Carson spring-chinook salmon strain are not included in this ESU. Spring-run chinook salmon in the Sandy River have been influenced by introductions of spring-run chinook salmon from the Willamette River ESU. However, analyses suggest that considerable genetic resources still reside in the existing population (NMFS 1998).

Historical Information

Historical records of chinook salmon abundance are sparse, but records from canneries suggest a peak run size of 4.6 million fish in 1883. Although fall-run chinook salmon are still present throughout much of their historical range, the majority of the fish spawning today are first-generation hatchery strays. Furthermore, spring-run populations have been severely depleted throughout the ESU, and extirpated from a number of rivers.

Life History

Fish in this ESU are considered ocean type; the majority emigrate to the ocean as subyearlings. Coded wire tag recoveries of Lower Columbia River ESU fish suggest a northerly migration route, but they apparently contribute little to the Alaskan fishery. Populations tend to mature at ages 3 and 4.

Habitat and Hydrology

As in other ESUs, chinook salmon have been affected by alteration of freshwater habitat (Bottom et al. 1985, WDF et al. 1993, Kostow 1995). Timber harvesting and associated road building peaked in the 1930s, but impacts from the timber industry still remain (Kostow 1995). Agriculture is also widespread in this ESU and has affected riparian vegetation and stream hydrology. This ESU is also highly affected by urbanization including river diking and channelization, drain and fill of wetlands, and pollution (Kostow 1995).

Hatchery Influence

The Lower Columbia River ESU has been subject to intensive hatchery influence. Hatchery programs to enhance chinook salmon fisheries in the lower Columbia River began in the 1870s, releasing billions of fish over time. This equals the total hatchery releases for all other chinook ESUs combined (Myers et al. 1998). Although the majority of the stocks have come from within this ESU, over 200 million fish from outside the ESU have been released since 1930 (Myers et al. 1998).

A-6 Snake River Steelhead

Geographic Boundaries and Spatial Distribution

Steelhead spawning habitat in the Snake River is distinctive in having large areas of open, low-relief streams at high elevations. In many Snake River tributaries, spawning occurs at a higher elevation (up to 2,000 m) than is found for steelhead in any other geographic region. Snake River Basin steelhead also migrate farther from the ocean (up to 1,500 km) than most.

Historical Information

No estimates of historical (pre-1960s) abundance specific to this ESU are available.

Life History (Including Ocean)

Fish in this ESU are summer steelhead. They enter fresh water from June to October and spawn during the following spring from March to May. Two groups have been identified, based on migration timing, ocean-age, and adult size. “A-run” steelhead, thought to be predominately age-1-ocean, enter freshwater during June through August. “B-run” steelhead, thought to be age-2-ocean, enter freshwater during August through October. “B-run” steelhead are typically 75-100 mm longer at the same age. Both groups usually smolt as 2- or 3-year-olds (Whitt 1954, BPA 1992, Hassemer 1992).

Habitat and Hydrology

Hydropower projects create several substantial habitat blockages in this ESU; the major ones include the Hells Canyon Dam complex (mainstem Snake River) and Dworshak Dam (North Fork Clearwater River). Minor blockages are common throughout the region. Steelhead spawning areas have been degraded by overgrazing, as well as by historical gold dredging and sedimentation due to poor land management practices. Habitat in the Snake basin is warmer and drier and often more eroded than elsewhere in the Columbia River basin or in coastal areas.

Hatchery Influence
Hatchery fish are widespread and stray to spawn naturally throughout the region. In the 1990s, an average of 86% of adult steelhead passing Lower Granite Dam were of hatchery origin. However, hatchery contribution to naturally spawning populations is variable across the region; some stocks are dominated by hatchery fish, whereas others are composed of all wild fish.

A-7 Upper Columbia River Steelhead

Geographic boundaries and spatial distribution

This ESU occupies the Columbia River Basin upstream from the Yakima River. Rivers in this area primarily drain the east slope of the northern Cascade Mountains and include the Wenatchee, Entiat, Methow, and Okanogan river basins. Climate in this area includes extremes in temperature and precipitation; most precipitation falls as mountain snow (Mullan et al.1992). The river valleys are deeply dissected and maintain low gradients except for the extreme headwaters (Franklin and Dyrness 1973).

Historical information

Estimates of historical (pre-1960s) abundance specific to this ESU are available from fish counts at dams. Counts at Rock Island Dam from 1933 to 1959 averaged 2,600-3,700, suggesting a pre-fishery run size in excess of 5,000 adults for tributaries above Rock Island Dam (Chapman et al. 1994). However, runs may already have been depressed by lower Columbia River fisheries at this time.

Life history

As in other inland ESUs (the Snake and Mid-Columbia river basins), steelhead in the Upper Columbia River ESU remain in fresh water up to a year prior to spawning. Smolt age is dominated by 2-year-olds. Based on limited data, steelhead from the Wenatchee and Entiat rivers return to fresh water after 1 year in salt water, whereas Methow River steelhead are primarily age-2-ocean (Howell et al. 1985). Life history characteristics for Upper Columbia River basin steelhead are similar to those of other inland steelhead ESUs; however, some of the oldest smolt ages for steelhead, up to 7 years, are reported from this ESU. The relationship between anadromous and nonanadromous forms in this geographic area is unclear.

Habitat and hydrology

Substantial habitat blockages occurred with the construction of Chief Joseph and Grand Coulee Dams, as well as smaller dams on tributary rivers. Habitat issues for this ESU are largely related to irrigation diversions and hydroelectric dams, as well as degraded riparian and instream habitat from urbanization and livestock grazing.

Hatchery influence

Hatchery fish are widespread and escaping to spawn naturally throughout the region. Spawning escapement is strongly dominated by hatchery production.

A-8 Middle Columbia River Steelhead

Geographic Boundaries and Spatial Distribution

This ESU occupies the Columbia River basin from above the Wind River in Washington and the Hood River in Oregon upstream to include the Yakima River, Washington. This region includes some of the driest areas of the Pacific Northwest, generally receiving less than 40 cm of precipitation annually (Jackson 1993). Summer steelhead are widespread throughout the ESU; winter steelhead occur in Mosier, Chenowith, Mill and Fifteenmile creeks, Oregon, and in the Klickitat and White Salmon rivers in Washington. The John Day River probably represents the largest native, natural spawning stock of steelhead in the region.

Historical Information

Estimates of historical (pre-1960s) abundance specific to this ESU are available for the Yakima River, with an estimated run size of 100,000 (WDF et al. 1993). Assuming comparable run sizes for other drainage areas in this ESU, the total historical run size may have exceeded 300,000 steelhead.

Life History

Most fish in this ESU smolt at 2 years and spend 1 to 2 years in salt water prior to re-entering fresh water, where they may remain up to a year prior to spawning (Howell et al. 1985, BPA 1992). All steelhead upstream from The Dalles Dam are summer-run (Schreck et al. 1986, Reisenbichler et al. 1992, Chapman et al. 1994). However, the Klickitat River produces both summer and winter steelhead and the summer steelhead are dominated by age-2-ocean steelhead, whereas most other rivers in this region produce about equal numbers of both age-1- and 2-ocean fish. A nonanadromous form co-occurs with the anadromous form within this ESU; information suggests that the two forms may not be reproductively isolated, except where barriers are involved.

Habitat and Hydrology

The only substantial habitat blockage at present in this ESU is at Pelton Dam on the Deschutes River, but minor blockages occur throughout the region. Water withdrawals and overgrazing have seriously reduced summer flows in the principal summer steelhead spawning and rearing tributaries of the Deschutes River. This is significant because high summer and low winter temperatures are limiting factors for salmonids in many streams in this region (Bottom et al. 1985).

Hatchery Influence

Continued increases in the proportion of stray steelhead in the Deschutes River basin is a major source of concern. The ODFW and CTWSRO estimate that 60% to 80% of the naturally-spawning population is composed of strays, which greatly outnumber naturally-produced fish. Although the level of reproductive success of these stray fish has not been evaluated, the levels are so high that major genetic and ecological effects on natural populations are possible (Busby et al. 1999).

The negative effects of any interbreeding that may occur between stray and native steelhead will be exacerbated if the stray steelhead originated in geographically distant river basins, especially if those river basins are in different ESUs. The populations of steelhead in the Deschutes River basin include (1) steelhead native to the Deschutes River, (2) hatchery steelhead from the Round Butte Hatchery on the Deschutes River, (3) wild steelhead strays from other rivers in the Columbia River basin, and(4) hatchery steelhead strays from other Columbia River basin streams. Regarding the latter, the CTWSRO has reported preliminary findings from a tagging study conducted by T. Bjornn and M. Jepson (University of Idaho) and NMFS suggesting that a large fraction of the steelhead passing through Columbia River dams (e.g., John Day and Lower Granite dams) have "dipped" into the Deschutes River and then returned to the mainstem Columbia River. A key unresolved question regarding the large number of strays in the Deschutes basin is how many stray fish actually remain in the basin and spawn naturally.

A-9 Upper Willamette River Steelhead

Geographic Boundaries and Spatial Distribution

The Upper Willamette River steelhead ESU occupies the Willamette River and tributaries upstream from the Willamette Falls extending to the Calapooia River, inclusive. These major river basins containing spawning and rearing habitat comprise more than 12,000 km^2 in Oregon. Rivers that contain naturally spawning winter-run steelhead include the Tualatin, Mollala, Santiam, Calapooia, Yamhill, Rickreall, Luckiamute and Mary's River, although there is debate about the origin and distribution of steelhead in a number of these basins. Early migrating winter and summer steelhead have been introduced into the Upper Willamette River basin; however these components are not part of this ESU.

Historical Information

Native winter steelhead within this ESU have been declining since 1971 and have exhibited large fluctuations in abundance.

Life History

In general, native steelhead of the Upper Willamette River Basin are late-migrating winter steelhead, entering fresh water primarily in March and April. This atypical run timing appears to be an adaptation for ascending Willamette Falls, which functions as an isolating mechanism for upper Willamette River steelhead. Reproductive isolation resulting from the falls may explain the genetic distinction between steelhead from the upper Willamette River basin and those in the lower river. Willamette River late-migrating steelhead are ocean-maturing fish; the majority return at age 4 with a small proportion returning as 5 year olds (Busby et al. 1996).

Habitat and Hydrology

Willamette Falls (RKm 77) is a known migration barrier – winter steelhead and spring chinook salmon occurred above the falls historically whereas summer steelhead, fall chinook, and coho salmon did not. Detroit and Big Cliff Dams cut off 540 km of spawning and rearing habitat in the North Santiam River. In general, habitat in this ESU has become substantially simplified since the 1800s through removal of large woody debris to increase the navigability of the river.

Hatchery Influence

The main hatchery production of native (late-run) winter steelhead occurs in the North Fork Santiam River, where estimates of hatchery proportion in natural spawning areas range from 14% to 54% (Busby et al. 1996). More recent estimates of the percent of naturally spawning fish attributable to hatcheries in the late 1990s are 24% in the Molalla, 17% in the North Santiam, 5% to 12% in the South Santiam, and less than 5% in the Calapooia (ODFW and Chilcote 1997, 1998 as cited in Busby et al. 1999).

A-10 Lower Columbia River Steelhead

Geographic Boundaries and Spatial Distribution

The Lower Columbia River ESU encompasses all steelhead runs in tributaries between the Cowlitz and Wind rivers on the Washington side of the Columbia, and the Willamette and Hood rivers on the Oregon side. The populations of steelhead that make up the Lower Columbia River ESU are distinguished from adjacent populations on the basis of genetic and habitat characteristics. This ESU consists of summer and winter coastal steelhead runs in the tributaries of the Columbia River as it passes through the Cascade Crest. These populations are genetically distinct from inland (east of the Cascades) populations, as well as from steelhead populations in the Upper Willamette basin and coastal runs north and south of the Columbia River mouth. Not included in the ESU are runs in the Willamette River above the Clackamas (Upper Willamette River ESU), runs in the Little and Big White Salmon rivers (Middle Columbia River ESU) and runs based on four imported hatchery stocks: early-spawning winter Chambers Creek/Lower Columbia River mix, summer Skamania Hatchery stock, winter Eagle Creek NFH stock, and winter Clackamas River ODFW stock (NMFS 1998). Within this area there are at least 36 distinct runs (Busby 1996), 20 of which were identified in the initial listing petition. In addition, there are numerous small tributaries for which there are historical reports of fish, but no current abundance data. The major runs in the ESU, for which there are estimates of run size, are: Cowlitz River winter runs, Toutle River winter runs, Kalama River winter and summer runs, Lewis River winter and summer runs, Washougal River winter and summer runs, Wind River summer runs, Clackamas River winter and summer runs, Sandy River winter and summer runs, and Hood River winter and summer runs.

Historical Information

For the larger runs, current counts have been in the range of 1 to 2,000 fish (Cowlitz, Kalama, and Sandy rivers), however historical counts put these runs at more than 20,000 fish. In general, all runs in the ESU have been declining over the past 20 years, experiencing sharp declines in the past 5 years.

Habitat and Hydrology

Steelhead in this ESU are thought to make extensive use of estuarine habitats during out-migration, smoltification and spawning migrations. The lower reaches of the Columbia River are highly modified through urbanization and dredging for navigation. The upland areas covered by this ESU are extensively logged, affecting water quality in the smaller streams used primarily by summer runs. In addition, all major tributaries used by Lower Columbia River steelhead have some form of hydraulic barrier that impedes fish passage. These structures range from impassible structures in the Sandy River basin that preclude access to extensive historically occupied steelhead habitat, to passable but disruptive projects on the Cowlitz and Lewis Rivers. The overall impact of hydropower-activities on this ESU was seen as an important determinant of extinction risk by the Biological Review Team (1997).

Hatchery Influence

Many populations of steelhead in the Lower Columbia River ESU are dominated by hatchery escapement. Roughly 500,000 hatchery raised steelhead are released into drainages within this ESU each year. As a result, first generation hatchery fish are thought to make up 50% to 80% of the fish counted on natural spawning grounds. The impact of hatchery fish is not uniform, however. Several runs are mostly hatchery strays (e.g., the winter run in the Cowlitz River [92%] and the Kalama River [77%], the summer run in the North Fork Washougal River [50%]) whereas others are almost free of hatchery influence (the summer run in the mainstem Washougal River [0%] and winter runs in the North Fork Toutle and Wind rivers [0% to 1%]).

Other

Escapement estimates for the steelhead fishery in the Lower Columbia River ESU are based on in-river and estuary sport-fishing reports; there is a very limited ocean fishery on this ESU. Harvest rates range from 20% to 50% on the total run, but for hatchery-wild differentiated stocks, harvest rates on wild fish have dropped to 0% to 4% in recent years (punch card data from WDFW through 1994).

A-11 Columbia River Chum Salmon

Geographic Boundaries and Spatial Distribution

Chum salmon of the Columbia River ESU spawn in tributaries and in a single known mainstem spawning area below Bonneville Dam. The majority of fish spawn on the Washington side of the Columbia River (Johnson et al. 1997).

Historical Information

Previously, chum salmon were reported to be present in almost every river in the lower Columbia River Basin, but most of these runs disappeared by the 1950s (Rich 1942, Marr 1943, Fulton 1970). Currently, the Washington Department of Fish and Wildlife (WDFW) regularly monitors only a few natural populations in the basin, one in Grays River, two in small streams near Bonneville Dam, and the mainstem area adjacent to one of the latter two streams.

Life History

Chum salmon enter the Columbia River from mid-October through early December and spawn from early November to late December. Recent genetic analysis of fish from Hardy and Hamilton creeks and from the Grays River indicate that these fish are genetically distinct from other chum salmon populations in Washington. Levels of genetic variability within and between populations in several geographic areas are similar, and populations in Washington show levels of genetic subdivision typical of those seen between summer- and fall-run populations in other areas and typical of populations within run types (Salo 1991, WDF et al. 1993, Phelps et al. 1994, and Johnson et al. 1997).

Other

Historically, the Columbia River Chum Salmon ESU supported a large commercial fishery with landings above 500,000 fish per year. Commercial catches declined beginning in the mid-1950s. There are presently neither recreational nor directed commercial fisheries for chum salmon in the Columbia River, although some chum salmon are taken incidentally in the gill-net fisheries for coho and chinook salmon and there is a minor recreational harvest in some tributaries (WDF et al. 1993).

A-12 Snake River Sockeye Salmon

Geographic Boundaries and Spatial Distribution

The only remaining sockeye in the Snake River system are found in Redfish Lake, on the Salmon River. The nonanadromous form (kokanee), found in Redfish Lake and elsewhere in the Snake River basin, are included in the ESU.

Historical Information

Snake River sockeye historically were abundant in several lake systems in Idaho and Oregon. However, all populations have been extirpated during the past century except those fish returning to Redfish Lake.

Life History

In general, juvenile sockeye salmon rear in the lake environment for 1, 2, or 3 years before migrating to sea. Adults typically return to the natal lake system to spawn after spending 1, 2, 3, or 4 years in the ocean (Gustafson et al, 1997).

Habitat and Hydrology

In 1910, impassable Sunbeam Dam was constructed 20 miles downstream from Redfish Lake. Although several fish ladders and a diversion tunnel were put in during subsequent decades, it is unclear whether enough fish passed above the dam to sustain the run. The dam was partially removed in 1934, after which Redfish Lake runs partially rebounded. There is mixed evidence as to whether these restored runs constitute anadromous forms that managed to persist during the dam years, non-anadromous forms that became migratory, or fish that strayed in from outside the ESU.