AN ABSTRACT OF THE THESIS OF

Chad C. Meengs for the degree of Master of Science in Environmental Science presented on July 12, 2004.
Title: The Size of the Oregon Coastal Salmon Runs in the Mid-1800s.

Abstra Redacted for Privacy

Robert T. Lackey

Abstract.- Increasing the abundance of salmon in coastal Oregon rivers and streams is a high priority public policy objective. Salmon runs have been reduced from pre-development conditions (typically defined as the 1850s), but it is unclear by how much. Considerable resources have been allocated to restoring salmon runs, but it is uncertain what the current recovery potential is because much of the freshwater and estuarine habitat for salmon has been altered. The goals of all recovery efforts are based on assumptions, often unstated, for what the size if the runs were prior to significant habitat alteration, coupled with an estimate of the amount and quality of freshwater and estuarine habitat currently available. At one extreme, it may be that current run sizes reflect the recovery potential of the existing salmon habitat. At the other extreme, the recovery potential may be as high as the mid 1800 levels. Historical salmon runs sizes on the Oregon coast were estimated using two methods: (1) Converting aboriginal population levels and their salmon consumption rate into numbers of salmon; (2) Extrapolating cannery pack into numbers of salmon. Annual aboriginal harvest of all salmon species is estimated to have been approximately 10 million pounds/year or between 1.75 million and 5.36 million salmonids, a harvest level similar to that occurring during the height of commercial fishing on Oregon's coastal rivers in the late 1800s and early 1900s. Extrapolating cannery pack data, the estimated size of the late 1800s aggregate runs of coho (Oncorhynchus kisutch) was 1.5-2.5 million. The estimated size of aggregate runs of chinook (Oncorhynchus tshawytscha) runs was 290,000-517,000. Compared to mid 1800s coho estimates, current runs (during favorable ocean conditions), are 11-19%. During poor ocean conditions, current coho runs are 3-6% of the historical size.

The Size of the Oregon Coastal Salmon Runs in the Mid-1800s

by
Chad C. Meengs

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CHAPTER 1

INTRODUCTION

Naturally spawning populations of coho (Oncorhynchus kisutch) salmon on the Oregon coast were listed by the National Oceanic and Atmospheric Administration under the Endangered Species Act (ESA) on August 10, 1998. ESA listing made recovery of wild salmon a legal mandate of the Federal government. The ESA listings of various salmon Evolutionarily Significant Units (ESUs) in the Northwest have already cost billions of dollars, but has had mixed results in recovering wild salmon (Lewallen and Brooks 2002). An ESU in a population or group of populations of salmon that: 1) is substantially reproductively isolated from other populations; and 2) contributes substantially to the ecological/genetic diversity of the biological species. This term is used by NMFS in its status determinations for anadromous salmon populations (61 FR 4721).

One of the difficulties in the recovery effort is selecting recovery goals. Scientists have yet to determine the quantity of salmon the Oregon coastal watersheds can naturally (without supplementation from hatcheries or other methods) support, and what type of habitat is the most critical for wild salmon recovery. Therefore, to realistically address wild salmon recovery, scientists must first determine the quantity of salmon the Oregon coastal watersheds can support, or the maximum recovery potential.

One approach to calculate the maximum recovery potential is to determine how many salmon the Oregon coastal streams supported prior to significant habitat alteration (~1850), and then adjust this estimate to reflect the habitat currently available. Once the maximum recovery potential is determined scientists and policy makers can use this information to prioritize habitat restoration projects. Prioritization is important because it is extremely unlikely to bring today's habitat back to the 1850s state, and funds for restoration will always be limited.

Recovery of wild salmon runs is also challenging because ocean conditions, weather patterns, habitat, harvest, and hatcheries all play a role in determining salmon abundance. Humans can do little to change ocean conditions and weather patterns over a century time scale. Hatchery practices can be adjusted to reduce their effects on wild salmon, but there is little evidence that public support for supplemental stocking will subside in the near future. Further, public pressure to continue fishing is likely to remain high, and salmon released from hatcheries often supply that need.

Improving habitat has traditionally been one of the key tactics for recovering salmon. Habitat is an extremely important component in the survival of Pacific salmon, and also an area that society can change in ways that will help recover wild salmon runs. Therefore, knowing the nature and extent of historical habitat, present restoration efforts can be made more effective and efficient.

First (chapter 2), historical salmon abundance will be reconstructed by analyzing anthropological research that evaluated the extent of salmon consumption by aboriginal inhabitants of the Oregon coast. Studies have shown that salmon abundance is a good predictor of aboriginal populations (Baunhoff 1963, Sneed 1972, Donald and Mitchell 1975, Hunn 1982). Therefore, with an estimated aboriginal population, coupled with overall aboriginal salmon consumption and harvest rates, it is possible to extrapolate the size of the runs.

Second (chapter 3), historical runs will be reconstructed by analyzing early (1800s) written records and Oregon's coastal salmon cannery pack. Cannery records are the longest continuous record of salmon harvest on the Oregon Coast. Using cannery data it is possible to extrapolate salmon runs by converting the salmon cannery pack to numbers of salmon and then applying a catch efficiency rate. Prior estimates were made on the Oregon coast by Mullen (1981b), and Lichatowich (1989) using Oregon's cannery pack, however this paper will bring forth new evidence suggesting that earlier estimates may have been low.

Third (chapter 4), changes in coastal salmon habitat from the mid-1800s to the present will be described. Habitat alteration on the Oregon coast and elsewhere has potentially greatly reduced Oregon's coastal streams salmon carrying capacity. Because available freshwater and estuarine habitat likely constrain the long-term abundance of wild salmon, it is essential to determine the quantity of habitat that is currently available. Some current estimates exist for coastal wetlands. For example, since the early 1850s, Oregon's original tidal wetland area has decreased by an estimated 68 percent, and about 25 percent of the total area of estuaries has been lost (Jackson 1991). However, there are no region-wide estimates for freshwater habitats.

Fourth (chapter 5), the maximum realistic recovery potential of wild salmon for the Oregon coast will be estimated by adjusting historical estimates of abundance to reflect current habitat conditions. Recovery potential should provide an approximate upper limit on long-term sustainable runs.

CHAPTER 2

RECONSTRUCTING HISTORICAL SALMON RUN SIZE EXTRAPOLATING FROM ESTIMATED ABORIGINAL POPULATIONS

The watersheds of the Oregon coast are important in maintaining the long-term viability of wild salmon in the contiguous western U.S. because they represent some of the least altered salmon habitat. Watersheds such as the Columbia and Sacramento, although once major salmon producing areas, are highly altered by human actions and the recovery potential for wild salmon is now severely constrained.

Oregon's coastal region, as defined here, is the area of the coast south of the Columbia River to the California border. The Columbia River and its tributaries are not included. Most of the coastal streams originate in the coastal mountains; however the Rogue and Umpqua basins are notable exceptions. The area described encompasses portions of two ESUs, Oregon Coast Coho Salmon ESU (Figure 1a), and Southern Oregon/Northern California Coasts Coho Salmon ESU (Figure 1b).

Figure 1a.—Map of Oregon Coast Coho Salmon ESU

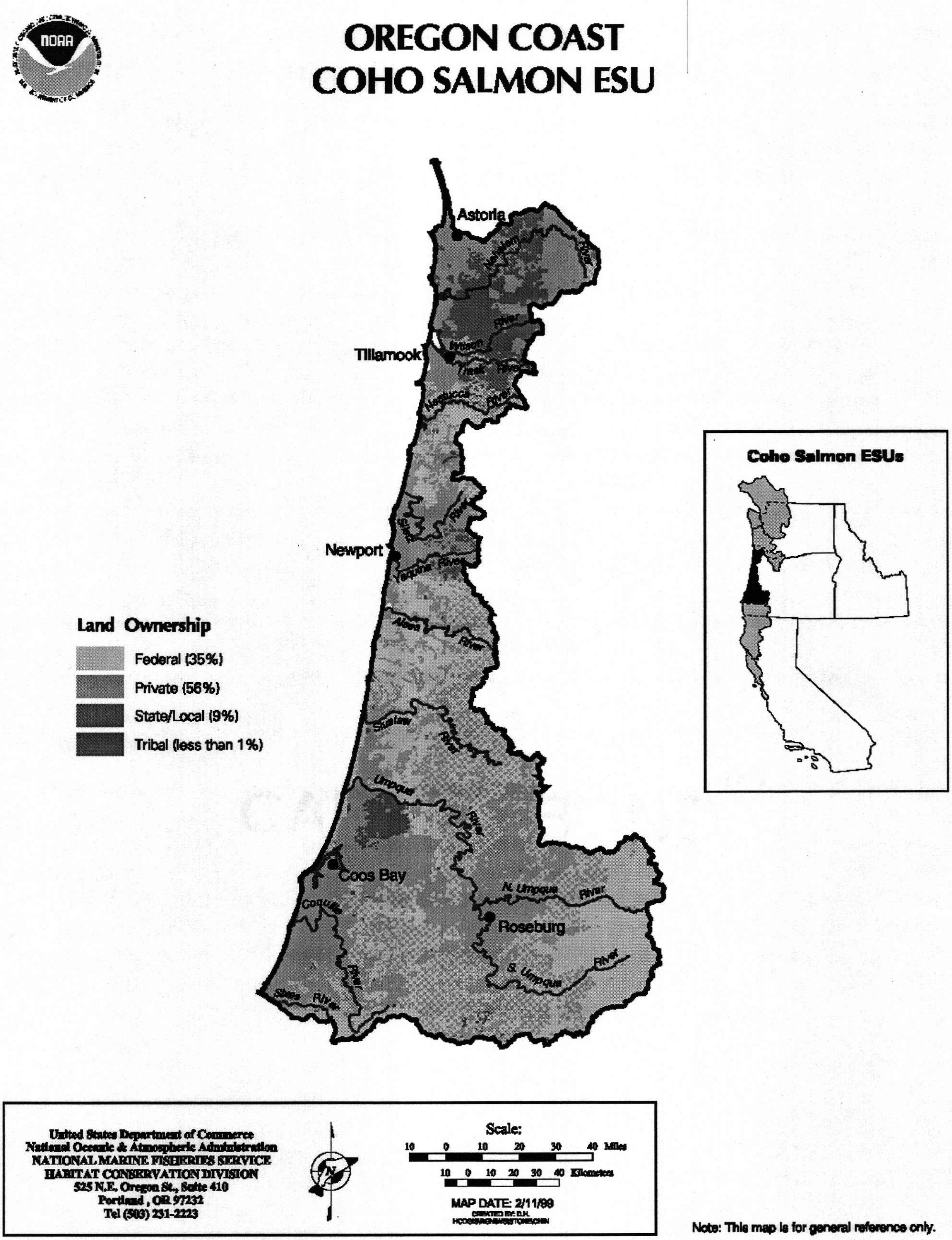
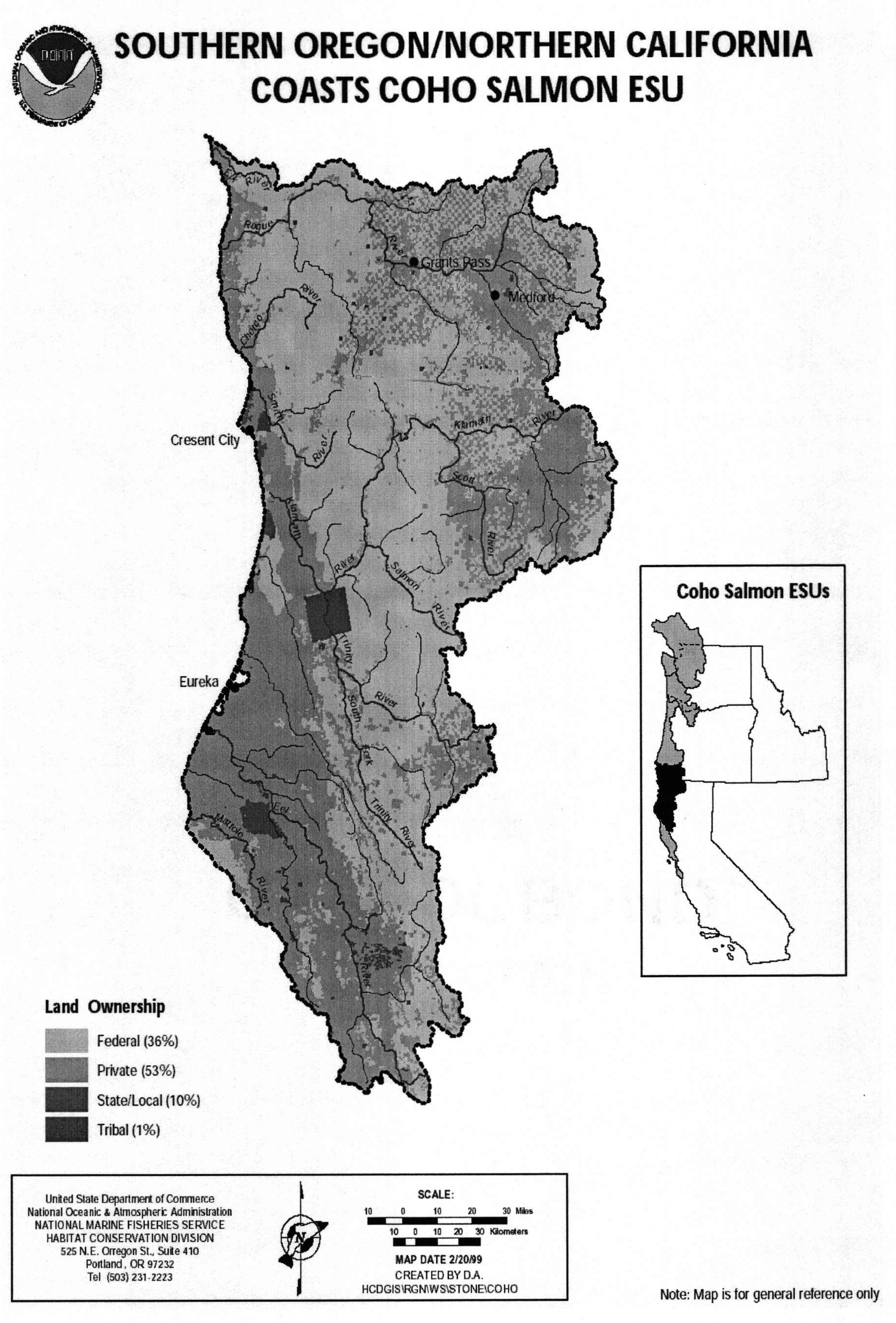


Figure 1b.--Map of Southern Oregon/Northern California Coasts Coho Salmon ESU



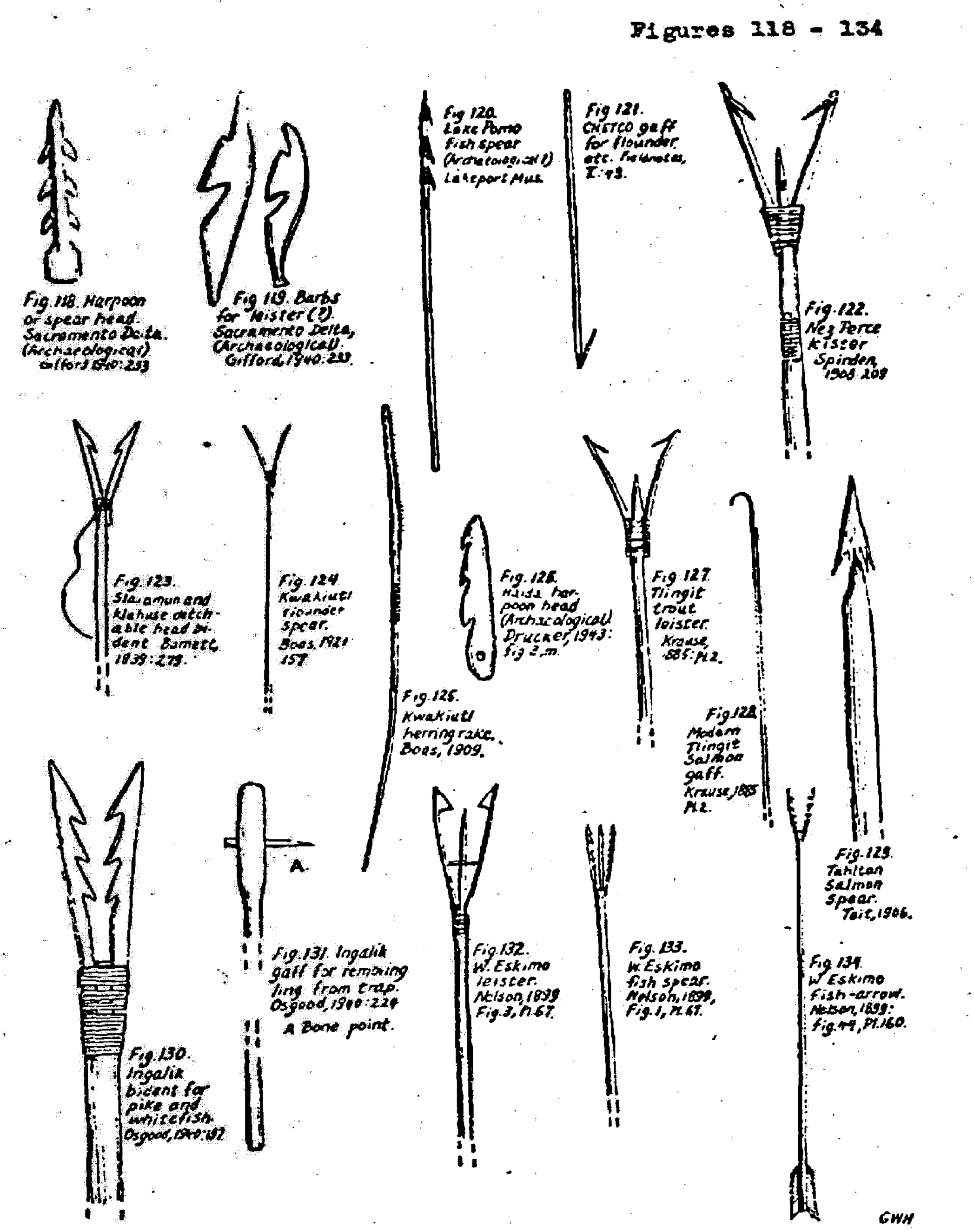
For the last 10,000 years aboriginal peoples have populated the Northwest Coastal area (the coastal area from Alaska to California) (Cressman 1977). In 1774 as many as 200,000 aboriginal peoples lived along the Northwest Coast, making it one of the most densely populated nonagricultural regions in the world. These people were hunters and gatherers, who specialized in harvesting salmon. They were more dependent on Pacific salmon than any other single food source and prospered along the Northwest coast because of the large salmon runs (Boyd 1990). Not only were the salmon abundant, they were also seasonally predictable, and could be dried for storage and lightweight transportation. This made it possible for aboriginals to return to a particular site at a consistent date and capture large quantities of fish. Overlapping runs and salmon curing provided coastal aboriginals with a nearly year-round supply of protein (Schalk 1986).

Due to their close nutritional tie to salmon and considering that the carry capacity of aboriginal populations was loosely regulated by salmon runs, it is possible to extrapolate salmon run size from an estimate of aboriginal population size and consumption rate. Aboriginal harvest of salmon was comparable to the harvest rates of the industrial fishery at its peak from 1883 to 1919 on the Columbia River and in California's central valley (Craig and Hacker 1940, Yoshiyama 1999).

ABORIGINAL POPULATIONS AND THEIR HARVEST OF SALMON

Aboriginal populations used a wide variety of techniques to harvest salmon at different sites (Figure 2). The most successful sites usually included a riffle or waterfall, places where salmon tended to congregate. From natural rock ledges or wood platforms over the stream, they were able to spear, harpoon, or dip net salmon. Aboriginals would return to successful sites year after year, generation after generation (Barnett 1937, Hewes 1973).

Figure 2.—Techniques, and tools used by aboriginals to harvest salmon



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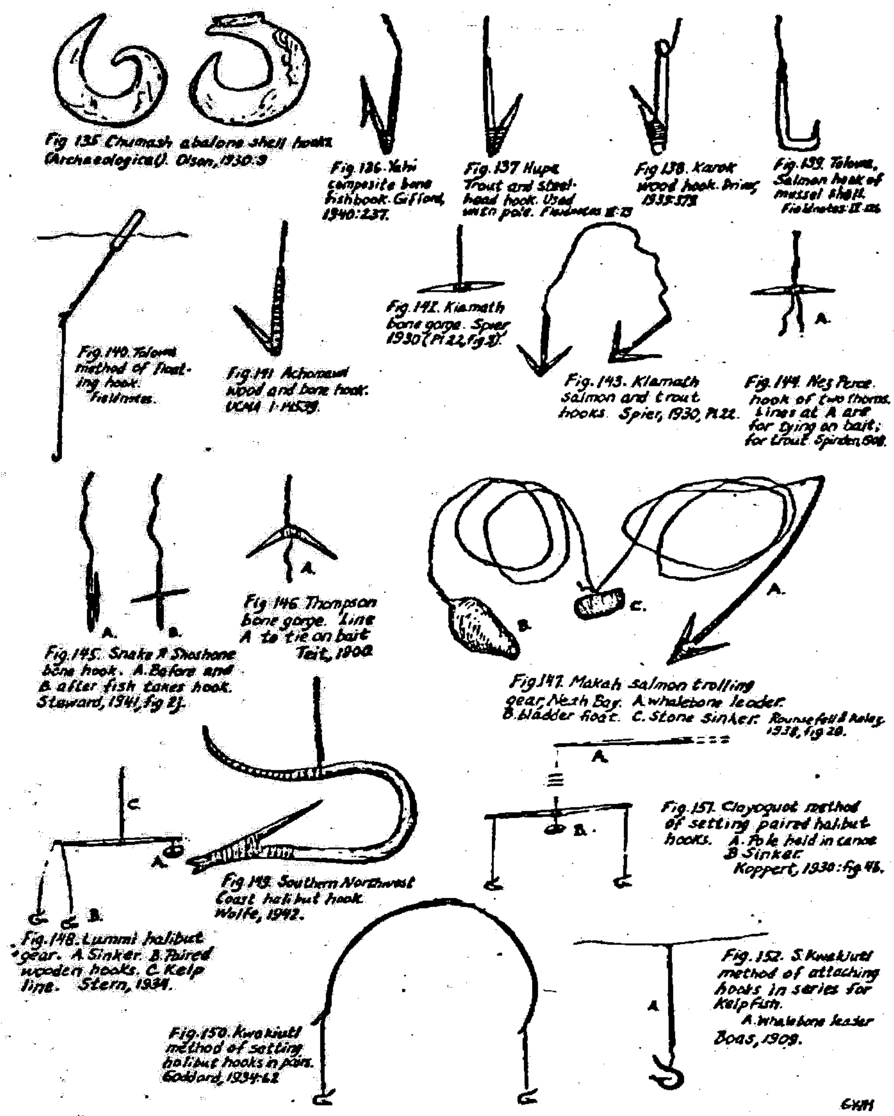

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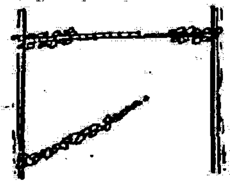


Fig. 19. Lillooet dam and weir. Ray 1942 p.259.

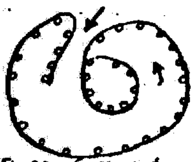
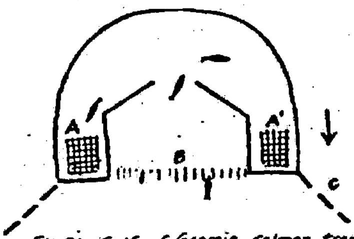


Fig 20. Comox and Pentlatch stone and stake fish-maze, for tidewater. Barnett. 1939, p.279.



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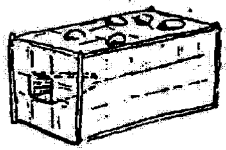
B. Inclined sticks.
C. Wings.
Barnett, 1939 279.



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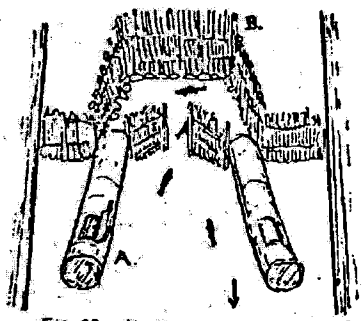

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Fig. 24. S. Kwakiutl overhanging log dam and stone enclosure for salmon-spearing. Boas, 1909.

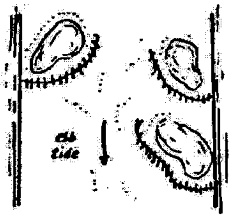


Fig 25. S. Kwakiutl tidal pool trap for inlet or estuary. Fences can also be of stone. Boas, 1909.

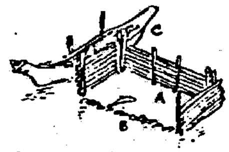


Fig. 26. S. Kwakiutl salmon trap on Nimpkish River.
A. Bottom covered with white stones or wood matting of light color.
B. Top of stone dam.
C. Canoe in which spearer waits.
GWH

(Hewes 1947)

In areas of slow water, such as estuaries, aboriginal peoples would use gill nets, seines, and weirs. They would also create impenetrable barriers on smaller streams, and occasionally use poisons to stun salmon (Barnett 1937). In many respects, aboriginal techniques equaled contemporary commercial fishing practices and could be very efficient (Hewes 1973). Aboriginal technology was effective and likely permitted catching more fish than actually needed (Craig and Hacker 1940).

In hunting and gathering populations, human carrying capacities were established by food resources during the "lean season" (Baunhoff 1963). Thus, salmon runs may have established the carrying capacity of the aboriginal population along the Oregon coast. For example, in the lower Klamath and Fraser rivers, as well as the coastal rivers of southern British Columbia, salmon productivity is a good predictor of aboriginal populations (Baunhoff 1963, Sneed 1972, Donald and Mitchell 1975, Hunn 1982). On the Columbia River the densest populations of aboriginal peoples were near historically good fishing sites. Oregon coastal aboriginals were "specialists" continually improving capture technology (Boyd 1990). Lastly, historical records show that famine occurred periodically during early spring before the first salmon of the season were caught (Smith 1983).

ABORIGINAL POPULATION AND SALMON CONSUMPTION RATE

Estimates of Oregon's aboriginal populations have evolved as better analytical techniques have developed. In the 1930s most historians estimated that the aboriginal population was 50,000 in the Columbia basin. Craig and Hacker (1940,) assuming that aboriginals each consumed one pound of salmon per day, calculated that aboriginals in the Columbia basin harvested 18,000,000 pounds of salmon per year. Swindell (1942) suggested that Oregon coastal aboriginal populations may have been even more dependent on salmon and most likely consumed more than 1 lb/day. Hewes (1973) used an updated population for the Columbia of 61,500 and recalculated aboriginal harvest to include fish that were wasted. He projected the estimated Columbia River catch at 22,274,500 pounds and the Oregon coastal catch at 5,600,000 pounds. Schalk (1986) with newer archaeological, ethnohistoric, and ethnographic data revised the aboriginal harvest to 41,754,800 pounds for the Columbia, an estimate that puts aboriginal harvest in the same range as the modern commercial harvest during its height (Craig and Hacker 1940). Far more disease epidemics occurred prior to the arrival of permanent immigrants from eastern North America than previously considered, thus the aboriginal populations were even higher than previously calculated (Boyd 1990). Boyd's aboriginal population estimate will be used here to calculate Oregon's coastal salmon run size.

CALCULATING OREGON'S COASTAL SALMON RUN SIZE

Schalk (1986) used a 3-pronged approach for determining the run size for the Columbia, and I will use it as a template for Oregon's coastal rivers. The first step is to use pre-existing data on how many pounds of salmon individual tribes consumed per capita per year. The second step is to follow Hunn's (1981) research showing that salmon will lose calories as they make their way back to their spawning grounds. The "caloric loss factor" is computed as a ratio of the distance from the mouth of the individual river to the middle of each tribe's territory to the entire length of that river.

This ratio is then multiplied by the average value for calorie loss during salmon migration, 0.75, and the product is subtracted from one. The third component involves dividing the per capita consumption estimate by a waste loss factor of 0.8 which yields the weight of the fish utilized by aboriginal people; (Table 1). Hunn (1982) suggested that 80% of the total salmon was edible (Table 1; Figure 3).

Table 1.Oregon coast—estimated pounds of salmon caught by aboriginals using migration calorie loss and waste factors.

Aboriginal Group	Pop. Size[a] (Boyd 1990)	Per Capital salmon meat consumed[b]	Caloric loss factor[c]	Per Capita salmon meat consumed converted for caloric loss[d]	Per Capita salmon meat consumed converted for caloric loss and waste[e]	Annual harvest[f] (lbs)
Tlatskanai	1,600	365	.97	376	470	752,000
Tillamook	4,320	365	1	365	456	1,970,000
Alseans	3,060	365	1	365	456	1,395,000
Siuslawans	2,100	365	1	365	456	958,000
Coosans	2,250	365	1	365	456	1,026,000
Coastal Athapascans	4,500	365	1	365	456	2,052,000
(Takilma) Interior Athapscans	4,500	300	.90	333	416	1,875,000
TOTAL						10,025,000

Note: The data are calculated in the following manner. First multiply, Swindell's (1942) per capita estimate (b) by the migration calorie loss factor (c) to get a weight estimate (d). Next divide the weight estimate (d) by 0.8 to get the per capita annual weight estimate (e). Lastly multiply (e) by the individual aboriginal populations (a). Using these calculations it is possible to arrive at an annual harvest (in pounds) for salmon along the Oregon coast, (10,025,000 lbs.) (f).

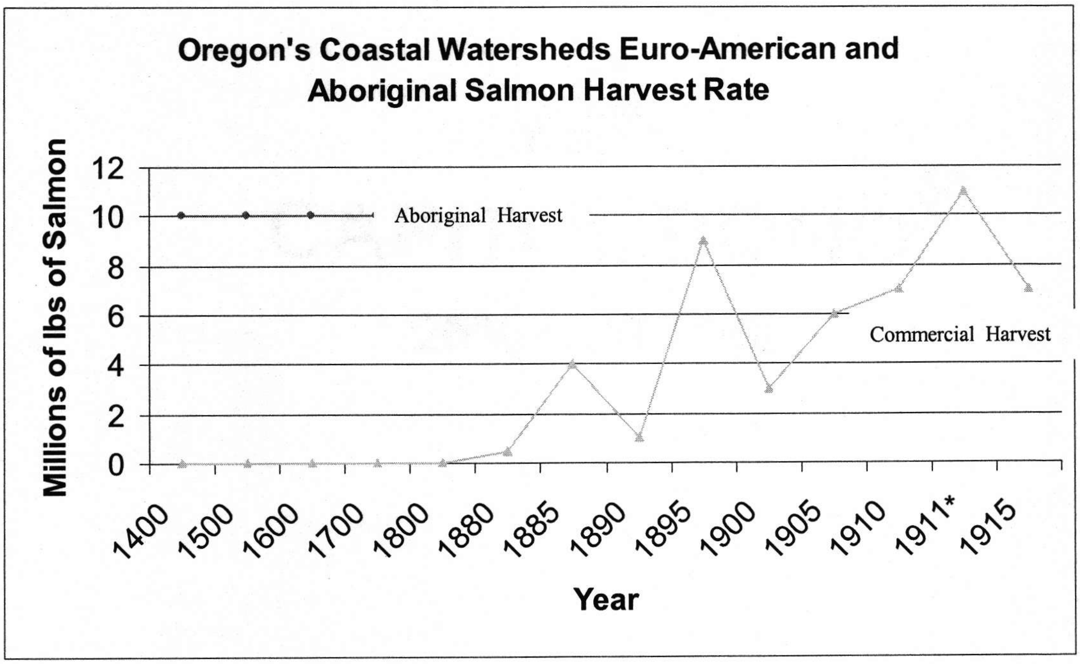


Figure 3.—A comparison of salmon harvested estimates by aboriginal peoples and Euro-Americans from 1400-1915. *1911 represents the highest cannery pack for the Oregon coast between the 1880s and 1920; canneries processed 11,273,000 lbs. of salmon.

Fourth, convert the pounds of fish to numbers of fish harvested. Northwest Power Planning Council (NWPPC) (1986) converted Schalks' total pounds of fish to numbers of fish for the Columbia. Assuming that the aboriginal catch had the same species proportions as the commercial catch from 1880 to 1920, they determined an average for all of the species of salmon were between 6.62 lbs and 9.27 lbs. Converting the total catch in pounds to numbers of individual salmon, aboriginals harvested between 1 and 1.5 million salmon from Oregon's coastal rivers. Lastly, to estimate the total historical run size, Craig and Hacker (1940) estimated that the aboriginal populations harvested between 28 and 57 percent of the run (depending on the run size). Further extrapolating aboriginal population data, the estimated size of the total salmon run along the Oregon coast was between 1.75 million and 5.36 million salmonids. Craig and Hacker's estimate (and thus the above estimates) could be low because their estimates only took into account what aboriginal populations used for food. There is little doubt that fish were used for other purposes (e.g. feeding domestic dogs, trade, fuel, and loss to scavengers). For example, during the Lewis and Clark expedition, it was noted that the dogs of the aboriginals' were typically skinny before the arrival of the salmon in the spring and fat when salmon were abundant (Thwaites 1905).

Assuming the aboriginal harvest was similar to the size of the industrial fishing, how were aboriginal populations able to harvest such large quantities of fish and still coexist with salmon for thousands of years? Perhaps, as some argue selective pressure can actually be beneficial for a species (Rostlund 1952). All species produce more progeny than needed to maintain the population in the absence of unusual mortality. The excess is needed to offset losses from predation, competition, disease, etc. Without exploitation, it is possible that too many salmon use the spawning grounds (over spawning), causing severe competition and loss of previously deposited eggs. Second, aboriginals would harvest fish throughout the entire river basin, a practice that would result in a relatively even thinning of the population throughout the whole system (Schalk 1986). In contrast, industrial fishing was usually located near river mouths, and often focused on particular species and runs. Lastly, aboriginals were well aware of their dependence on salmon, and employed social restrictions to help assure continuing runs. It was often a cultural taboo to waste or to take more salmon than needed (Hunn 1982).

DECLINE OF INDIGINOUS POPULATIONS AND ITS EFFECT ON SALMON POPULATIONS

The rate at which aboriginal populations declined, and the rate at which Euro-American populations moved into the Pacific Northwest was very dramatic. By 1900 the aboriginal population in Oregon had decreased by 95%, while Euro-Americans increased from less than 800 in 1840 to more than 1.1 million in 1900.

Introduced diseases were the leading cause of death for all aboriginal populations in the Pacific Northwest (Boyd 1985, 1990). Prior to Euro-American expansion, aboriginals were dying from interpersonal violence, endemic diseases, warfare, and starvation (Gould 1981). However, until the first non-endemic diseases (smallpox) in the late 1770's, aboriginal populations were reasonably stable (Cressman 1977).

The Euro-American diseases that most afflicted the aboriginal population were smallpox, malaria, measles, influenza, dysentery, whooping cough, typhus, and typhoid fever. Smallpox was the first European disease to reach the Pacific Northwest. A Spanish expedition which landed on the Northwest coast in 1775 was most likely the source of the initial outbreak. The second outbreak occurred in 1801 on the central coast. Each outbreak killed approximately 1/3 of the aboriginal population exposed to the disease (Crosby 1972, Boyd 1990). However, the mortality rate was probably significantly lower during the second outbreak as some immunity had already developed (Smith 1958). A third outbreak hit in the mid-1820s with a mortality rate between 10 and 20 percent. A fourth wave of smallpox hit the Northwest coast between 1836 and 1838.

In the 1830s a second non-indigenous disease (malaria) reached the Northwest coast. Between 1830 and 1841, the mortality rate exceeded 85 percent, nearly extirpating the aboriginal population in the Willamette Valley. The effect of the malarial outbreak was exacerbated because aboriginal populations had to deal with malaria and smallpox simultaneously. The combination of the two diseases claimed another third of the infected population.

In the 1840s, the first permanent White settlers brought whooping cough, measles, typhoid fever, influenza, and dysentery. Although these new diseases were not as virulent as smallpox or malaria, they still took a toll (Crosby 1972, Boyd 1990). Combined they accounted for a 10 percent mortality rate (Boyd 1990). In 1853 smallpox returned with an even more virulent strain where 40 percent of the aboriginal population that contracted the disease died. Smallpox resurfaced again in

1862. In total from 1774 to 1900 the aboriginal population along the Northwest coast dropped from 200,000 to 10,000 as a result of introduced infectious diseases (Boyd 1985, 1990)

This precipitous drop in the aboriginal population most likely affected the size of salmon runs. First, salmon runs may have been larger in the 1850s than just about any other time in post glacial history due to the fact that the aboriginal population was no longer harvesting large quantities of fish (Craig and Hacker 1940, Hewes 1947). Other hypotheses suggest that the salmon population would briefly increase, and then fall to a new equilibrium due to the increased intraspecific competition on the spawning grounds (Van Hyning 1973, Chapman 1982).

RISE OF THE EURO-AMERICANS

As aboriginal populations declined throughout the mid-1800s Euro-American populations were rising. In 1841 less than 800 Euro-Americans had settled in the Willamette Valley. By the end of 1845, 5,100 non-indigenous people inhabited Western Oregon. Five years later in 1850, 12,093 people lived in Oregon. Oregon City, Portland, Salem, and Astoria exhibited rapid growth (Dicken and Dicken 1979). The first Euro-Americans were mostly traders and farmers, but in 1851 gold was found in the Rogue River basin, causing a second wave of immigration to Oregon.

By 1860, the non-aboriginal population had grown to 52, 923. Ten years later this figure nearly doubled to 90,923 (Figure 4). By 1880, the population of Euro-Americans reached 174,923, by 1890; 317,923, and by the 1900s; 408,585 non-indigenous people remained. By 1900, only 4,951 aboriginal people were left in

Oregon. In a little over 100 years the aboriginal population had declined by 95%, while the non-Indigenous population increased more than one thousand times (Dicken and Dicken 1979).

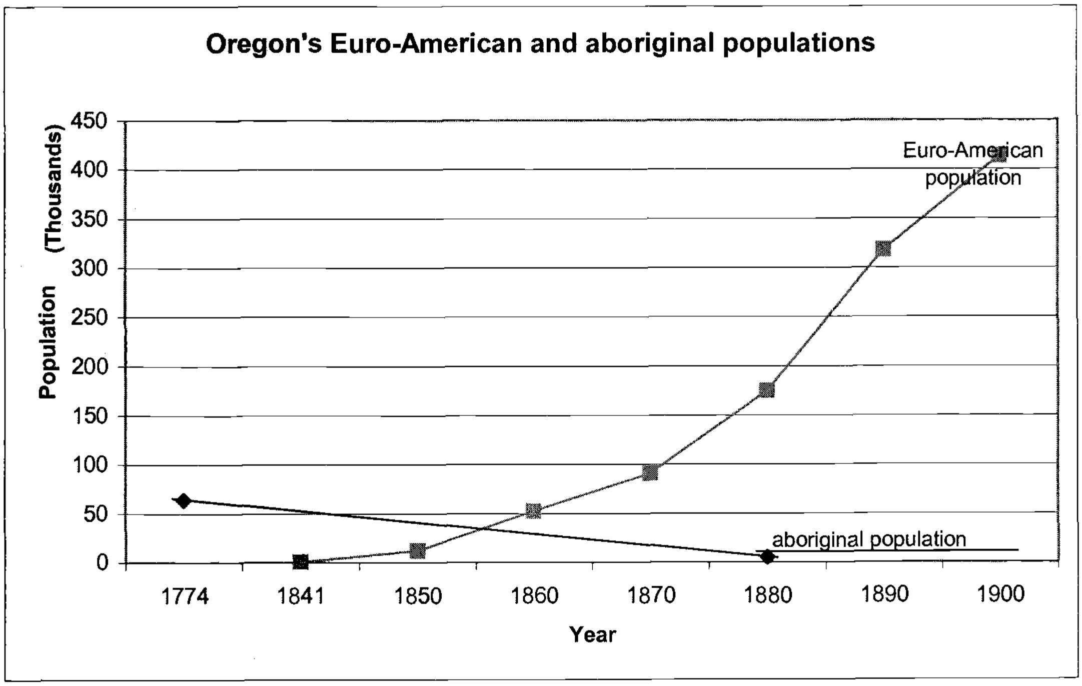


Figure 4 .–Decline in the aboriginal population and the rise in the Euro-American population. This transformation in population dynamics transformed the landscape of Oregon, thus, affecting Oregon's salmon runs.

CHAPTER 3

RECONSTRUCTING HISTORICAL RUNS THROUGH ANALYSIS OF EARLY CANNERY RECORDS

EURO-AMERICAN AND ENVIRONMENTAL CHANGES AFFECTING SALMON PRIOR TO THE START OF THE CANNERY HARVEST IN 1876

Both aboriginals and early Euro-Americans relied on natural resources for their existence; however Euro-Americans exported these natural resources to a much greater degree. Traders exported furs, salmon, wheat, and logs. The fur trade was probably the first Euro-American influence on salmon abundance. Traders decimated the beaver population, depressing the structural diversity of streams and decreasing the quantity, and quality of habitat for juvenile salmonids. By the 1840s agriculture was well established in Oregon territory. Farmers brought in exotic crops such as wheat, barley, potatoes, fruits, and vegetables, which rapidly changed the flora in these areas (Dicken and Dicken 1979).

However, the anthropogenic effects on salmon in coastal Oregon were likely minor until 1851 when miners found gold in the Illinois River. Soon after, mining towns developed throughout southern Oregon and by 1864, prospecting had spread throughout the state (Dicken and Dicken 1979).

Placer mining, the earliest type of gold mining, consisted of excavating large quantities of sand and sediment by hand, then panning by hand. This type of mining probably only had minimal impacts on salmon. By 1856 the first hydraulic mining operations in Oregon started, which revolutionized the way miners extracted gold (See Appendix A, B) (Dicken and Dicken 1979). Gravity fed ditches diverted large quantities of water into pipes, supplying miners with pressurized water. Miners would then use the pressurized water to blast away gold bearing hillsides, washing all excess sediment into the streams and rivers. Entire hillsides would be washed into these streams, suffocating adult salmon and smothering redds. For example, early mining dumped enough material into the Rogue that the entire river turned reddish-yellow (Ward 1938). Mercury and other chemicals leached from gold mines changed the river's pH. Furthermore, diversion dams used to collect water to support hydraulic mining rarely had fishways; blocking adult passage as well as diverting juveniles and then blasted out of the water cannons. During the summer months these diversions would also severely reduced river levels.

By 1865 mining had eliminated salmon runs from the Boise River, Idaho (Gilbert and Evermann 1894). During the summer of 1871, miners diverted about half of the Rogue River flow into the mining works at Big Bar, causing the water level to drop and the temperature to rise. Mining operations like Big Bar not only washed tons of sediment into rivers, it also drastically changed the overall landscape of the rivers (*Morning Oregonian* 1886).

The rapid rise of Oregon's population due to the mining boom stimulated demand for agricultural products, which in turn lowered floral diversity, and increased sedimentation of Oregon's rivers. For example, farming started in the Tillamook basin in the 1850s and 1860s (Swift 1909). Wheat production increased from 211,000 acres in 1850 to 2,389,000 acres in 1870. Dairy cows also increased from 9,000 to 48,000 in that same time period (Dicken and Dicken 1979). To keep up with the new demand, farms converted unplowed land into agricultural land.

Heavy siltation from agriculture increased noticeably in the Columbia during the mid 1880s (Morning Oregonian 1879). Heavy agricultural irrigating caused river levels to drop even further. Agricultural dams blocked the rivers and lacked fish passages. Livestock grazing altered landscapes significantly in the upper Grand Ronde above La Grande by the 1880s and the Applegate watershed by the 1900s (McIntosh 1994).

Logging further affected salmon runs by reducing available and altering existing salmon habitat. Early logging activities were focused around the Willamette Valley and the lower Columbia, Tillamook, Yaquina, Coos, and Umpqua basins. Three sawmills were started in Tillamook bay in 1863 (Levesque 1985). In 1872 sixteen vessels arrived in Coos Bay for lumber each week (Dicken and Dicken 1979). Loggers would harvest trees in easily accessible areas, often not more than a mile from river transport (Holbrock 1956). As a consequence, riparian zones where the first areas to be harvested. Reducing streamside cover often elevated water temperature, eroded banks, and increased sediment loads (See Appendix C,D) (Chapman 1962).

Transporting logs also adversely affected salmon. During the mid-1880s eleven Western Oregon streams had logjams from 100 to 1500 feet in length, often making it very difficult or impossible for adult salmon to pass. In smaller streams and rivers, splash dams were a common practice. Loggers began using splash dams in coastal streams in the early 1870s. They would let the water build up behind the dams until there was enough to flush the logs down to the mills, at times almost completely blocking the water flow. By 1910 there were one hundred and sixty splash dams on costal rivers and lower Columbia tributaries in Oregon (See Appendix E) (Sedell and Luchessa 1982).

Splash dams not only obstructed stream flow, they also damaged salmon habitat when breached. Once the streams were backed up sufficiently enough to transport the logs to the mill, loggers would rapidly release the water. The resulting high stream flows eroded banks and filled in deep pools, which might have been the last refuge for juvenile salmon given the low water levels (Chapman 1962, Sedell and Luchessa 1982). Saw mills also dumped tons of sawdust into streams and bays, further smothering fish, redds, and other aquatic life (Chapman 1962). By the 1860s, prior to the first canneries on the Oregon coast, trappers, farmers, irrigators, and loggers had already significantly reduced the spawning and rearing range of salmon along Oregon's coast (Craig and Hacker 1940).

CANNERY HISTORY

Pacific Northwest aboriginal peoples traded salmon with visiting ships as early as 1792 (Howay 1990). This trade became more substantial in the early 1800s when permanent forts were established in Oregon (Merk 1968). In 1823 the Hudson's Bay Company started developing additional markets for salmon, and in 1824 tried sending barrels of salted salmon to London, but they spoiled during the long trips (Merk 1968). This small-scale salting practice continued until 1865 when Andrew Hapgood and William, George, and R.D. Hume established the first cannery on the Columbia at Eagle Point (Deloach 1939, Smith 1979).

Hapgood, Hume, and Company packed 272,000 pounds of salmon in 1866 on the Columbia. By 1870 there were five Columbia canneries processing 10,000,000 pounds of salmon annually. Five years later, in 1875, 14 Columbia canneries canned 25,000,000 pounds; by 1884 thirty-seven canneries packed 42,000,000 pounds (Cobb 1930, Smith 1979).

For the Columbia, by the late 1870s the amount of salmon had decreased, corresponding to increased fishing pressure. In 1876, R.D. Hume stared building a cannery on the Rogue River after hearing rumors of large salmon runs. His brother, George W. Hume, also saw potential on the Oregon coast and built a cannery on the Umpqua River in 1878. By 1887 there were canneries on the Nehalem River, Tillamook Bay, Nestucca River, Yaquina Bay, Alsea Bay, Siuslaw River, Coos Bay, Rogue River, Umpqua River, and Coquille River. In 1896, a cannery was opened on the Siletz River making it the 11^{th} river basin to have a cannery on the Oregon Coast (See Appendix F,G).

In 1877 R.D. Hume's cannery on the Rogue River processed 7,804 cases of salmon. Ten years later in 1888, when 14 canneries were running on the Oregon coast, the pack was 73,996 cases. From 1888 to 1920, the salmon pack fluctuated greatly from 24,500 cases in 1891 to as many as 138,146 cases in 1911 (Cobb 1930). This large fluctuation appears to be due to natural as well as anthropogentric causes (Dodds 1959).

In 1930, Cobb summarized cannery production for the Oregon coast dating back until 1877. This cannery pack is the longest continuous record of salmon abundance on the Oregon coast. Using this data set, several scientists have estimated past salmon runs for the Columbia basin, and the Oregon Coast (Mullen 1981a, Chapman 1986, Lichatowich 1989, Gresh et al. 2000). Although each used slightly different methods, they each employed three common components to extrapolate run size:

(1) Convert salmon pack data from cases of salmon to numbers of salmon;

(2) Select a time period to represent typical run size. For example, Chapman used the five consecutive years that yielded the highest average, whereas Lichatowich used the highest yielding years and averaged them; and

(3) Estimate what fraction of the total run was caught and canned by applying a catch efficiency rate.

CONVERTING CASES OF SALMON TO NUMBERS OF SALMON

Not all of an individual salmon was canned; the head, fins, and organs were discarded or processed in a different manner. To account for this Craig and Hacker (1940), Mullen (1981a) converted each 48-pound case of salmon to 68 pounds of total salmon biomass. Thus, by multiplying the number of cases packed by 68 it is possible to convert cases of salmon into pounds of salmon caught.

To determine the number of salmon, an average weight must be estimated. Depending on the assumed weight for an individual salmon, there are drastically different results. Chapman (1982) used estimates of, 22.99 lbs for Chinook and 6.99 lbs for coho. Lichatowich (1989) used Bigler's (1996) estimates of 19.8 lbs for Chinook and 9.9 lbs for coho. I used Mullen's (1981a) estimate of 10.49 for coho, and Craig and Hacker's (1940) estimate of 23.25 for chinook because they were assessing on the Oregon coast.

Cannery data must also be adjusted for waste. Often more fish were caught than could be canned. Further, with limited cooling technology, salmon would often spoil and be discarded. For example, in 1896, a huge run of salmon entered the Columbia River. One canner said that the run was so numerous, "that the canneries, run to there [sic] greatest capacity, could not put up near all the fish, probably about one-half," (M.J. Kenney to W. de C. Ravenal (22 Aug. 1896). This type of waste might have accounted for as much as 50 percent of the Fraser River sockeye salmon harvest (Ricker 1987). Gresh (2000) assumed the waste of unused fish was 25 percent of the cannery pack for the entire Pacific Northwest (Gresh 2000)

Waste in cannery operations was not evenly distributed throughout the Pacific Northwest. It typically increased when salmon prices were low and when multiple canneries were located on a river system. Fisherman would often catch salmon, then save only the size and species that would yield the best price at the canneries. When competition was high between canneries, salmon would be caught, killed, and discarded trying to prevent other canneries from reaching their quota (Marchak 1988). This type of fierce competition was not as prevalent on the Oregon coast as it was in Columbia and other locations in the Pacific Northwest where numerous canneries were located on one river system. Individual river systems on the Oregon Coast often only had one cannery in operation at a time.

Some cannery operators on the Oregon coast made the connection between their own existence and profitability to the next years run, and therefore would not take more than could be canned or sold (Dodds 1959). Due to the lack of competition and stricter regulations, on the Oregon coast during the late 1800s, it seems reasonable to use an estimate that is less than half of Gresh's (2000) waste estimate for the Pacific Northwest, or 10 percent of the harvest.

Cannery data must also be adjusted for those salmon caught and sold without being canned. Salmon that were harvested were often sold fresh, salted, smoked, and pickled; and were not accounted for in the cannery pack. In 1901, 94 percent of the total Oregon coastal catch was canned, but by 1923 only 32 percent of the salmon harvested were being canned (Mullen 1981b). Reliable records were not kept for all of the years in between so an exact correction factor cannot be calculated. However, as the Oregon coastal fishery developed, a greater percentage of the harvest was sold fresh (Gharrett and Hodges 1950). It seems reasonable to assume a low estimate of 10 percent for this correction factor.

The last correction factor that must be made to Cobb's (1930) data set is to account for all of the other rivers and lakes on the Oregon coast that were not included in the original data set. The river systems that had canneries, and therefore were included in Cobb's data set were the Nehalem River, Tillamook Bay, Nestucca River, Yaquina Bay, Alsea Bay, Siuslaw River, Coos Bay, Rogue River, Umpqua River, Siletz River, and Coquille River. Cobb states that fish caught in the Chetco and Windchuck Rivers were either pickled or sold to the California canneries, therefore fish from these systems did not show up in Oregon's cannery records. The Nucanicum River, being only 10 miles south of the Columbia, most likely showed up in the Columbia pack, and not the coastal rivers pack (Cobb 1930). Cobb only mentions two other rivers in his data set, the Sixes River, and the Elk River. Fish caught in these two systems were either salted or sold to canneries on the Coquille River (Cobb 1930).

Fish were being brought from other rivers to the 11 cannery rivers, however this exchange was most likely very small until 1915 when non-motorized vessels were being converted into gas engines (Smith 1979), and until roads and railroads were built to connect coastal communities (Cobb 1930). Before 1920 the cannery pack probably closely reflected the actual catches for the river system that the canneries were located on (Mullen 1981a). To try to minimize the influence of outside systems, I only used Cobb's (1930) case pack until 1915.

Many of the rivers without canneries were extremely productive, and must be accounted for in Oregon's coastal salmon populations as a whole. According to Chenoweth (1972), " With the coming of the railroad to Tenmile lake, Columbia River gill-netters used to ship their boats by train to Tenmile Lake and it is said in November 1920 these boats caught 500 tons (or 95,000 fish) of Salmon."

The Oregon Department of Fish and Wildlife has compiled estimates of salmon stock size on Tenmile Lake since 1955. In 1955 they estimated that 41,500 adults and 36,000 jacks spawned in the Tenmile Lake area. This is not including lake or ocean harvest, and must take into account years of over harvest and habitat alteration. Tenmile, Talkenitch, and Siltcoos were all extremely productive coho lakes in the 1950s even though lake habitat had already been significantly altered (Al Magie, personal communication 2003). The estimated numbers of coho salmon landed on the Salmon River (Lincoln County) in 1944 was 26,013 pounds or 2479 coho salmon. There are also hundreds of small streams with salmon runs that were not accounted for in the early cannery data.

Assuming a similar percentage in habitat change along the Oregon coast, it is possible to compare the river systems with canneries to the river systems without canneries. Using Oregon Department of Fish and Wildlife coho spawning miles, the total was partitioned into rivers with canneries and rivers without canneries. For example, the Tillamook River as well as all of the river and stream systems that run into Tillamook Bay were included in the "with canneries" section. The river systems with canneries account for 4,814 coho spawning miles, and the without canneries accounted for 588 spawning miles. By dividing 588 by 5,402 miles of total habitat, it is possible to extrapolate the percent of miles or habitat, not included in the cannery records. Thus, 10.9% of the overall habitat was not being accounted for in the harvest records, but needs to be included to accurately represent the historical coastal run size.

With all of the above correction factors, as well as Cobb's (1930) cannery pack the number of fish harvested for a particular year can be calculated. Mullen's (1981a) estimates were taken at five year intervals. Chapman (1982) used the average harvest for the five consecutive years that yielded the highest combined harvest. Five year averaging minimizes the effects of unusually good or bad years skewing the results. Lichatowich (1989) used the peak catch years rather than five consecutive years to avoid including years when the catch may have been reduced by market conditions (Johnson 1983). I used both methods.

Individual canneries did not always report their harvest for a certain year. For example, in 1911 the largest coho run reported in Cobb's records was missing all of the data from the Rogue River (Cobb 1930). To adjust for the missing data, I used a third method, one similar to Lichatowich's (1989) method where the peak catch years for each river system were added and averaged, and then all of the river systems were added together.

CALCULATING A HARVEST RATE

Harvest rates of salmon in Oregon's coastal rivers were not measured until the 1950s. Tag and recapture methods were used in the Alsea, Tillamook Bay, Nehalem, and Siletz. The estimated harvest rates in 1954 ranged from 12-32% (Cleaver 1951, Willis 1954, Henry 1955, 1964). Based on the above harvest statistics both Mullen (1981b) and Lichatowich (1989) estimated an average harvest rate of 40 percent because fishing was more severely restricted during the 1950s. In Chapman's (1986) salmon study on the Columbia River, he used the optimal harvest rate of 67 percent for predevelopment production of salmon on the Columbia River. This higher harvest rate for the Columbia is justified because there was far less fishing pressure on the Oregon coast during the late 1800s. By the time the fishery was well established in coastal watersheds, strict laws limiting harvest were already in place. In 1880, the Columbia had 29 canneries employing 4,000 people, and the Oregon coast rivers only had 2 canneries employing 95 people. By 1900, the Oregon coast was a productive fishery, however restrictions had long been limiting harvest rate. As early as 1878 a law was enacted prohibiting commercial fishing between sunset Saturday and sunset Sunday. In 1881 the commercial season was shortened to April 1 to November 15, and fixed gear such as traps, setnets, and weirs were restricted to only one-third the width of the river. In 1901 the only fixed gear allowed on Oregon's coastal streams was setnets. Some of these regulations would change from year to year depending on the river and the species that were being harvested; however as a whole these rules put more and more constraints on the fishery (Gharrett and Hodges 1950.

Using the procedure summarized above, the late 1800s coho run size was most likely between 1.5 million to 2.5 million, and Chinook run size was most likely between 290,000 to 517,000 (Table 2).

Table 2.—(late 1800s) estimated salmon run sizes for Oregon's coastal rivers based on extrapolations from cannery pack.

coho	
Top Five Consecutive Years	1,501,000
Top Yielding Years	1,992,000
Average of Individual Streams Systems Top Yielding Years	2,529,000

chinook	
Top Five Consecutive Years	290,000
Top Yielding Years	378,000
Average of Individual Streams Systems Top Yielding Years	517,000

Individual river systems			
Nehalem River	236,000 coho 44,000 chinook	Siuslaw River	547,000 coho 23,000 chinook
Tillamook Bay[a]	234,000 coho 51,000 chinook	Umpqua River	199,000 coho 21,000 chinook
Nustucca River	107,000 coho 29,000 chinook	Coos Bay[a]	161,000 coho 55,000 chinook
Siletz River	122,000 coho 30,000 chinook	Coquille River	342,000 coho 14,000 chinook
Yaquina Bay[a]	65,000 coho 7,000 chinook	Rogue River	114,000 coho 154,000 chinook
Alsea Bay[a]	153,000 coho 38,000 chinook		

[a] Entries listed as Bay represent all streams and rivers entering into that bay.

CHAPTER 4

ESTIMATING CURRENTLY AVAILABLE SALMON HABITAT

Compared to early descriptions in technical reports, diaries, and government surveys, Oregon's coastal river habitat has changed considerably over the last 150 years. For example, one of the first of these surveys was completed in the Tillamook Bay area in the 1850s (Colton et al. 1996). The coastal environment consisted of meandering rivers and streams, large wood in and around the river system, and copious amounts of off-channel habitat. It is this type of complex habitat in which Pacific salmon have evolved (Sedell and Luchessa 1982). The distribution and abundance of salmon in 1850 in the Pacific Northwest is a reflection of more than 10,000 years of adaptations to the post-glacial environment and 4,000 to 5,000 years of adaptation to the temperate Oregon coastal climate (IMST 2002).

Many factors have had potential adverse effects on salmon populations, including poor ocean conditions, pollution, introduced species, drought, dams, hatchery bred fish, and land use alterations. All of the above are potentially important, however only some of the above can be managed or altered by humans.

In terms of wild fish recovery, available freshwater and ocean habitat, likely provides an upper bound for wild fish abundance, and thus needs to be quantified. The structure and process of the aquatic ecosystems are determined in large part by the interactions with adjacent ecosystems (Gregory, 2002a). Habitat alteration is one of the key factors determining the current status of salmonid populations in the Pacific Northwest (FEMAT 1993). Physical habitat alteration has been identified as a causal factor in 73% of fish species extinctions in North America during the past 100 years (Miller et al. 1989b). The river system is also connected; lowland rivers, streams, and estuaries are all connected to upland ecosystems, (Swanson et al. 1988, Gregory et al. 1991). For example, sedimentation due to logging in the upland ecosystem can affect estuarine productivity.

ESTUARINE ENVIRONMENT

One of the most drastic habitat changes along the Oregon coast is likely the alteration of the estuarine environment. The estuarine environment is a critical part of salmon life cycles because all anadromous salmon must pass through an estuary twice in their lifetime. If estuary conditions are not favorable, both juvenile and adult populations are affected (IMST 2002). Some salmonid species use the estuarine environment much more extensively than others. Chum salmon and chinook salmon, for example, are the most dependent on estuaries, and spend weeks to months feeding, rearing, and acclimating to the salt-water environment (Myers 1980, Groot and Margolis 1991). Estuaries are also important to adults returning to spawn, providing an opportunity to acclimate to the change in temperature and salinity in the river system.

The first major change in habitat in the estuarine environment was removing large wood. During the 1800s, rivers were usually viewed primarily as transportation corridors moving goods in and out of the interior (Sedell and Luchessa 1982). Rivers were straightened, dredged if necessary, and stripped of boulders, large wood, and other obstructions making the channel easily navigable (Sedell and Luchessa 1982). For example, the Coquille River system employed “snag boats” to clear out all obstacles starting in the 1840s and continuing until the 1970s (See Appendix H) (Sedell and Luchessa 1982). Some of these rivers were so filled with large wood the early explorer-trappers in 1826 were unable to explore much of the river (Ogden 1961). In 1888, in an annual report to Congress, the U.S. Army Corps of Engineers reported that, "the main obstacles to navigation for the slough to the town [Tillamook], besides its sharp bends, are snags and sunken drift" (Report of the Chief of Engineers, 1887-88, 1st session, 50th Congress, pp. 2150-1). Between 1890 and 1920, 9,300 snags from Tillamook Bay's channels were removed for navigational purposes (Benner and Sedell 1987). Large wood has been shown to be a key component in healthy salmon streams (Sedell and Luchessa 1982).

Other major changes included clearing, draining, dredging and channelizing the estuaries' wetland areas. At the turn of the century most of Tillamook Bay's lowlands were cleared of trees and all of the stumps had been removed. Meandering rivers in the low lands were straightened in order to take advantage of the fertile soil. In 1913 new draining practices were developed to drain Tillamook River's wetlands (Tillamook County Pioneer Association 1979). This newly claimed land was also used for agriculture and city expansion (Boule and Bierly 1987).

Overall, since the mid-1800s, Oregon's original tidal wetlands area has decreased by 68%; about 25% of the total area of estuaries has been lost (Jackson 1991). Such a decrease in habitat would be a major factor in the decline of salmon since 1850, and a limitation to the recovery potential (Table 3).

Table 3.—Changes in Oregon estuary wetlands from 1870 to 1979 (From SOER Panel 2000, table 3.32 pg. 26)

Estuary	**Actual 1970 Area (acres)**[1]		**Diked or Filled Tidal Wetland**[2]	**Estimated 1870 Area (acres)**[3]		**Percent Change (1870-1970)**	
	Tidal Wetland	Total Estuary		Tidal Wetland	Total Estuary	Tidal Wetland	Total Estuary
Columgia	16,150	119,220	30,050	46,200	149,270	-65%	20%
Necanicum	132	451	15	147	466	-10%	-3%
Nehalem	524	2,749	1,571	2,095	4,320	- 75%	-36%
Tillamook	884	9,216	3,274	4,158	12,490	-79%	-26%
Netarts	228	2,743	16	244	2,759	-7%	-1%
Sand Lake	462	897	9	471	906	-2%	-1%
Nestucca	205	1,176	2,160	2,365	3,336	-91%	-65%
Salmon	238	438	313	551	751	-57%	-42%
Siletz	274	1,461	401	675	1,862	-59%	-22%
Yaquina	621	4,349	1,493	2,114	5,842	-71%	-26%
Alsea	460	2,516	665	1,125	3,181	-59%	-21%
Siuslaw	746	3,060	1,256	2,002	4,316	-63%	-29%
Umpqua	1,201	6,544	1,218	2,419	7,762	-50%	-16%
Coos Bay	1,727	3,348	3,360	5,087	16,708	-66%	-20%
Coquille	276	1,082	4,600	4,876	5,682	-94%	-81%
Rogue	44	880	30	74	910	-41%	-3%
Chetco	4	171	5	9	176	-56%	-3%
TOTAL	24,176	160,301	50,436	74,612	220,737	-68%	-24%

RIPARIAN AREAS

Riparian zones are an integral part of a healthy (from a salmon's prospective) river ecosystem (Naiman et al. 1988, Gregory et al. 1991). Not only do these buffers control erosion, regulate the humidity, filter out particulates and pollution, provide shade, and protection from predators, they are also important inputs of Large Woody Debris (L.W.D) which is critical to the dynamics of the stream (Coulton et al. 1996b). When large riparian trees die and fall into the stream, they contribute extensively towards the retention of gravels, sediments, leaves, and other nutrients, as well as create a complex structure of, large pools, off-channel habitat, and backwaters (Sedell and Luchessa 1982, Brenner 1991, Coulton et al. 1996b). All of these different habitat components were important parts of the pre-settlement environment.

In the 1850s the riparian zone trees were often the first to be harvested. Water provided an efficient way to get the trees out of the forest and into the mills. By the late 1800s every river that could be used for log transport was being used to move the logs out of the forest and into the mills to be processed (Cox 1974). A new form of water transport, splash dams, was also in use. Water would be allowed to build up behind these dams until there was enough water to flush all of the logs down to the mills. When released the force of the water and logs would scour streambeds, destroy instream structure, and remove spawning gravel, completely changing the stream habitat. This practice often, removed all of the complex structure from the stream, leaving only a bedrock bottom. By 1900, over 160 splash dams were used on the coast and on the Columbia River tributaries (Sedell and Luchessa 1982). Between

1850 and 1990, hardwood, conifer, and mixed forests were reduced by over 75 percent along the Willamette River mainstem (Gregory et al. 2002a).

By the early 1900s, railroads made interior portions of forested watersheds accessible for harvesting (USDA 1966). This further decreased the large wood in and around the stream ecosystem. Lumber production increased dramatically after 1910 and, by 1938, Oregon was the country's leading producer of timber (Wall 1972). Wood removal continued to be an issue along Oregon's coast even in the late 1900s. Aerial photographs studied by Benner and Sedell (1987) documented a 73 percent decrease in the volume of wood at the mouths of the Tillamook, Siuslaw, Umpqua, and Coquille rivers between 1970 and 1985. Coinciding with this, the number of Forest Service free-use wood permits issued in the Pacific Northwest increased eight-fold between 1972 and 1984 (Gonar et. al 1988). By 1980 most of the mature Douglas fir, cedar, spruce, hemlock, and pine were removed from the riparian zones in the Pacific Northwest, being replaced by alder or second growth conifers, which do not have the same salmon habitat creating properties as large woody debris (Sedell et al. 1988). Naiman et al. (1992) found that usually the larger the woody debris, the better and more diverse the habitat was for salmonids.

OFF-CHANNEL HABITAT

Sedell et al. (1980) demonstrated that off-channel habitat or side channels have disproportionately large effects on salmon production in large rivers. Main channels, despite their large surface area, typically have lower salmonid densities, and biomass. Yuska et al. (1984) found that terrace-tributaries and side-channel habitats accounted for 6 percent of the total habitat available to salmonids on the south fork of the Hoh River, but accounted for 70% of the smolt production for the river. Beaver ponds, that were dry much of the year, had a survival rate for coho salmon about twice as high as the 35% estimated for the entire stream system (Bustard 1975). Due to channelization, removal of large wood, and flood control, there has been a significant reduction in river channel complexity, pools, riffles, overhangs, and backwater channels between 1860 and 1937 (Benner and Sedell 1987).

FLOOD-PLAIN ISOLATION

Flooding is an important process of the historical river landscape (Welcomme 1979). In unconstrained streams the flood plain can be a source of habitat, protection, and large wood. Over bank floods flush organisms, nutrients, and sediments into stream channels as flood waters recede, providing food for salmonids (Botkin 1994). If the river system becomes separated from its flood plain salmonids no longer have access to flood plain off-channel habitat, which is especially important for protection during freshets, or flood conditions (Sedell and Froggatt 1984). If the river is unconstrained large wood is added during flood conditions, or during lateral migration of the stream channel (Bilby and Bisson 1998).

In the late 1800s rivers were being isolated from their flood plains through channelization. During the 1900s, and especially after the 1948 and 1964 floods, people living in the floodplain demanded more protection for their homes and land. Dams and other structures were built in order to try to control these flooding events, further isolating the terrestrial environment from the aquatic environment.

DAMS, RESERVOIRS, WATER WITHDRAWAL, AND ROAD BUILDING

Dams and reservoirs have had less of an impact on the Oregon coast compared to the Columbia River Watershed. The potential losses in habitat area due to Lost Creek, Savage Rapids, Gold Ray, Winchester Dam, and Applegate Reservoir are not likely to be that much more than the amount of habitat that has been added by fish passage providing escapement around former natural barriers (PFMC 1979). For example, the fish passage on the Smith River added many miles of spawning and rearing habitat to the Umpqua system. However, it is very difficult to quantify the quality of habitat lost by dam and reservoir construction, versus the quality of habitat gained by the removal of natural barriers to migration. Oregon coast habitat deterioration in quality (from a salmon's perspective) has influenced salmon populations more than the construction of man-made barriers to migration (PFMC 1979).

Dams change river habitat more than just creating barriers to migration. Most dams on Oregon coastal rivers are also associated with water withdrawal. In Oregon, late summer is typically associated with high temperature and low flows; this is a crucial time for juvenile salmonids (Thompson and Fortune 1968). Summer also happens to coincide with high agricultural demand for livestock and irrigation. Agricultural withdrawal further decreases the habitat available; potentially increasing stream temperature, and causing fish to congregate in pools where they're more susceptible to disease and predation (Bottom et al. 1995). Road building has also changed habitat, and increased sediment loads on streams and rivers on the Oregon coast.

Alterations in salmon habitat, such as timber harvest, the construction of dams, and water withdrawal, are usually due to human actions to achieve other, non-salmon benefits. None of the habitat alterations taking place since 1850 were designed to harm salmon, but rather achieve other social, political, and economic objectives.

ADJUSTING HISTORICAL ESTIMATES OF SALMON ABUNDANCE TO REFLECT CURRENT HABITAT CONDITIONS

Extrapolating current salmon abundance using historical run estimates and then adjusting these estimates to reflect current habitat conditions to predict the maximum recovery potential is difficult given that some historical habitat has been lost all together, some has been altered, and lastly, the importance of different habitat types to individual species of salmon is not well understood.

Five experienced fisheries biologists were consulted, and asked to estimate the net loss of Oregon coastal salmon habitat. They estimated a 30-45% loss in productivity for chinook and a 45-70% loss in coho habitat. These assumptions are further evidenced by Beechie's findings that on the Skagit River the production capacity for coho have been reduced by 34%, not including the historical losses of the mainstem areas, and ponds (Beechie et al. 1994).

Based on aboriginal and cannery date, Oregon coastal coho run size was most likely between 1.5 million and 2.5 million, and chinook run size was most likely between 290,000 and 517,000. Combining this population estimate with the 30-45% reduction for chinook habitat and a 45-70% reduction for coho habitat in historical salmon productivity, it is possible to extrapolate the present day run size potential (Table 4).

Table 4 .—Chinook and coho run size for individual river systems along the Oregon coast

estimate	Historical estimate	Percent reduction	predicted present
Nehalem River			
coho	236,000	(45-70%)	71,000 -130,000
chinook	44,000	(30-45%)	24,000 - 31,000
Tillamook Bay and River			
coho	234,000	(45-70%)	70,000 -129,000
chinook	51,000	(30-45%)	28,000 - 36,000
Nustucca River			
coho	107,000	(45-70%)	32,000 - 59,000
chinook	29,000	(30-45%)	16,000 - 20,000
Siletz River			
coho	122,000	(45-70%)	37,000 - 67,000
chinook	30,000	(30-45%)	17,000 - 21,000
Yaquina Bay and River			
coho	65,000	(45-70%))	20,000 - 36,000
chinook	7,000	(30-45%)	4,000 - 5,000
Alsea Bay and River			
coho	153,000	(45-70%)	46,000 - 84,000
chinook	38,000	(30-45%)	21,000 - 27,000
Siuslaw River			
coho	547,000	(45-70%)	164,000-301,000
chinook	23,000	(30-45%)	13,000 - 16,000
Umpqua River			
coho	199,000	(45-70%)	60,000-109,000
chinook	21,000	(30-45%)	12,000 - 15,000
Coos Bay and River			
coho	161,000	(45-70%)	48,000 - 89,000
chinook	55,000	(30-45%)	30,000 - 39,000
Coquille River			
coho	342,000	(45-70%)	103,000-188,000
chinook	14,000	(30-45%)	8,000 -10,000
Rogue River			
coho	114,000	(45-70%)	34,000 - 63,000
chinook	154,000	(30-45%)	85,000 -108,000
Total (10.9%)			
coho	**2,280,000**	**(45-70%)**	**759,000 -1,391,000**
chinook	**466,000**	**(30-45%)**	**284,000 - 361,000**

If habitat and historical run size assumptions are correct, the present day run size for coho on the Oregon coast should be between 760,000 and 1.4 million, for chinook it should be between 284,000 and 361,000 but it is not.

CHAPTER 5

CONCLUSION

RECOVERY POTENTIAL

From a policy point perspective what is a realistic recovery potential under current habitat conditions? In the 1800s, when salmon habitat is assumed to have been intact, using aboriginal date, the annual aboriginal harvest rate of all salmon species is estimated to have been approximately 10 million pounds/year, or between 1.75 million and 5.36 million for all species. Extrapolating cannery data, the coho run size was most likely between 1.5 million and 2.5 million, and chinook run size was most likely between 290, 000 and 517,000 after considerable habitat alteration in the 1850s.

If freshwater and estuarine habitat is the limiting factor, the above historical run size estimates are correct, and if coho habitat has been reduced by 45 to 70%, then the present day run size for coho on the Oregon coast should be between 760,000 and 1.4 million. A comparison of the predicted present estimate to the current run size reveals that during poor ocean years the current run size is between 6 and 11% of the predicted run size while in good ocean years it is between 20 and 37% (Table 5a, Table 5b). Why is there such a large discrepancy in the predicted present estimate and the current estimate? The first, and most obvious, answer is error in the predicted present estimate of habitat quality and quantity. For example, maybe the current productive habitat is even lower than 30% of historical capacity. Other explanations include not habitat alterations; cyclical but declining ocean conditions available to

Oregon's coastal salmonid population, introduced exotic species, predation (bird, sea lion), increased pollution (agricultural, urban), hatcheries, etc.

Table 5a.— Recent coho run sizes for Oregon coastal rivers (ODFW)

	Current coho runs								
	1995	**1996**	**1997**	**1998**	**1999**	**2000**	**2001**	**2002**	**2003**
Nehalem River									
Wild	1,689	1,283	1,305	1,293	3,757	14,638	22,528	19,082	32,352
Hatchery	5,695	7,362	3,476	2,665	1,533	686	8,357	5,671	1,631
Total	7,384	8,645	4,781	3,958	5,290	15,324	30,885	24,753	33,983
Tillamook Bay and River									
Wild	290	662	389	272	2,175	1,983	1,893	15,270	13,246
Hatchery	7,414	1,036	803	1,484	3,979	4,673	17,270	12,641	5,014
Total	5,004	1,698	1,430	1,756	6,154	6,656	19,163	27,911	18,260
Nestucca River									
Wild	1,811	519	271	169	2,201	1,171	3,941	13,068	8,648
Hatchery	0	0	0	0	8	57	187	3	122
Total	1,811	519	271	169	2,209	1,228	4,128	13,071	8,770
Siletz River									
Wild	607	763	336	394	706	3,553	1,437	2,700	10,010
Hatchery	984	438	9	57	19	16	688	89	0
Total	1,591	1,201	345	451	725	3,569	2,125	2,789	10,010
Yaquina Bay and River									
Wild	5,668	5,127	384	365	2,588	647	3,039	24,415	13,074
Hatchery	0	4,367	2,297	3,155	7	52	268	0	21
Total	5,668	9,494	2,681	3,520	2,595	699	3,307	24,415	13,095
Alsea Bay and River									
Wild	724	1,687	718	270	2,082	2,465	3,339	6,260	8,661
Hatchery	3,241	4,170	4,278	7,688	1,008	60	772	72	2
Total	3,965	5,857	4,996	7,958	3,090	2,525	4,111	6,332	8,663
Siuslaw River									
Wild	6,089	7,625	668	1,089	2,724	6,767	11,024	56,971	29,397
Hatchery	0	2,708	44	161	216	75	56	171	11
Total	6.089	10,333	712	1,250	2,940	6,842	11,080	57,142	29,408
Umpqua River									
Wild	11,673	10,333	2,233	8,589	6,631	10,605	33,880	35,720	28,888
Hatchery	1,686	9,417	1,388	2,628	1,877	3,081	22,027	3,061	2,641
Total	13,359	19,750	3,621	11,217	8,508	13,686	55,907	38,781	31,529
Coos Bay and River									
Wild	10,374	12,156	1,136	3,189	4,967	5,406	43,391	35,453	31,688
Hatchery	1,085	475	224	314	282	532	1,821	2,291	3,058
Total	11,459	12,631	1,360	3,503	5,249	5,938	45,212	37,744	34,746
Coquille River									
Wild	2,117	16,186	5,723	2,467	3,038	6,130	13,322	8,553	27,045
Hatchery	22	568	133	98	263	613	2,956	259	744
Total	2,139	16,754	5,856	2,565	3,301	6,743	16,278	8,812	27,789
Rogue River									
Wild	3,761	4,622	8,282	2,316	1,438	10,966	12,213	7,800	6,754
Hatchery	9,550	8,699	8,710	3,131	4,755	10,177	13,166	12,759	7,296
Total	13,311	13,321	16,992	5,447	6,193	34,373	21,143	20,559	14,050
Totals for listed rivers									
Wild	44,803	60,963	20,727	20,413	32,307	64,331	150,007	225,292	209,763
Hatchery	22,296	39,240	21,362	24,901	12,939	20,022	67,568	37,017	20,540
Total	67,099	100,203	42,089	45,314	45,246	84,353	217,575	262,309	230,303
Percent wild	67%	61%	49%	45%	71%	76%	69%	86%	91%
Total coast wide	**92,624**	**128,354**	**56,176**	**63,575**	**71,239**	**113,161**	**277,752**	**315,674**	**251,782**

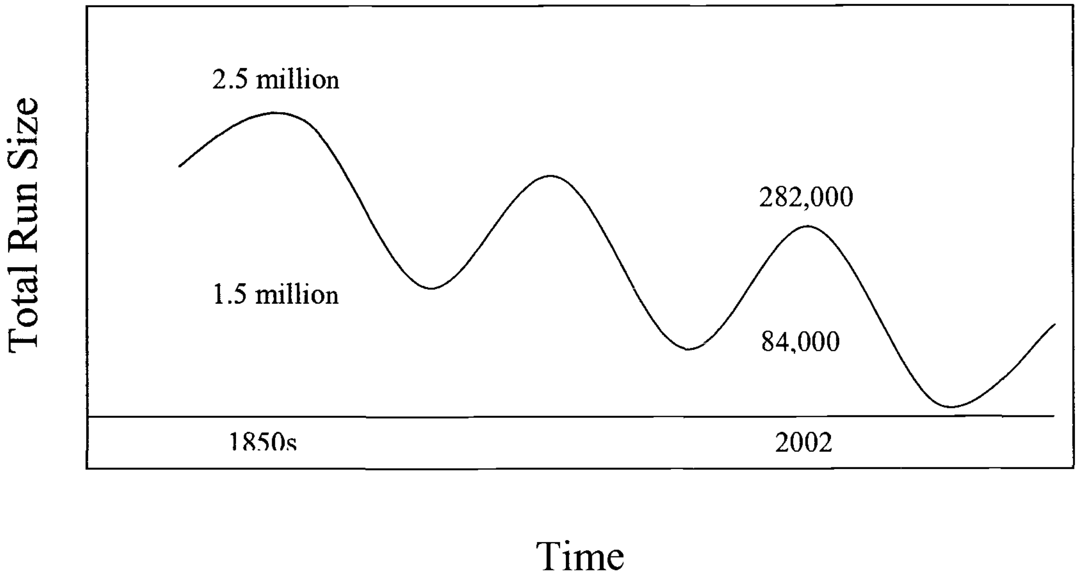
Table 5b.—Comparison of average coho run size for "good" and "poor" years with historical and average predicted current estimates in Oregon coastal rivers.

Historical estimates	Average Predicted current estimates	Average good ocean years	Average poor ocean years
1.5-2.5 million	759,000-1,391,000	281,736	84,188
% of historical		11-19	3-6
%of predicted		20-37	6-11

In "poor" ocean years the current run size is between 3-6%, and during "good" ocean years it is 11-19% of the historical estimates (these figures include hatchery coho) (Table 5b). Therefore, depending on ocean conditions coho runs have been reduced by 80-95% of since the 1850s

Given that in 2001, 2002, and 2003 the Oregon coast has experienced the highest run sizes in 30 years, and that the habitat has declined, this leaves ocean conditions as the most significant factor affecting run size fluctuation. Assuming that ocean conditions are at a cyclical peak (good conditions), the data indicates that current run sizes are at the upper end of the coho population (282,000) that can be supported by the currently available habitat. Under poor ocean conditions and with the current available habitat, the data infers the number of coho would be 84,000 (Figure 5).

Figure 5.— Hypothesized effects of habitat quality and ocean conditions on coho populations on the Oregon coast (Lawson 1993)



Consequently, current runs are approximately as large as can occur without major improvements in salmon freshwater and estuarine habitat given that ocean conditions are currently at an optimal level.

Estuaries and lowlands are, however, some of the most altered habitats along the Oregon coast. Research has also shown these habitats to be among the most critical for maintaining healthy coho runs. Improvements in these habitats will probably have the greatest payoff for enhancing runs of wild coho.

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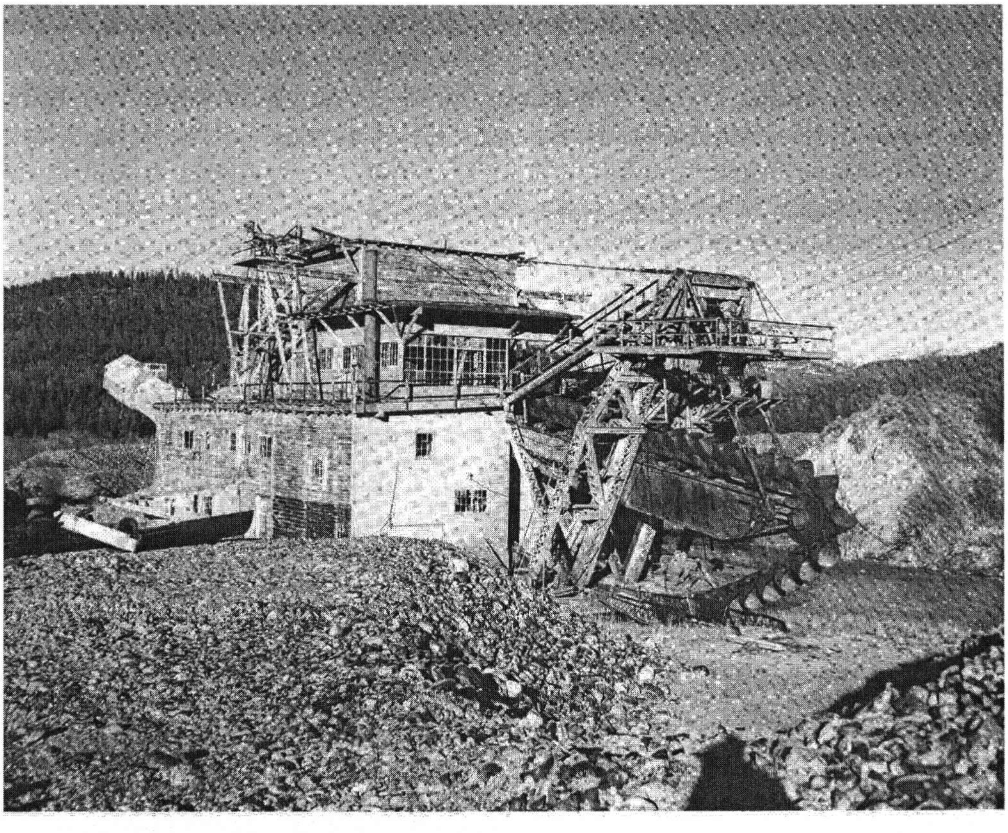
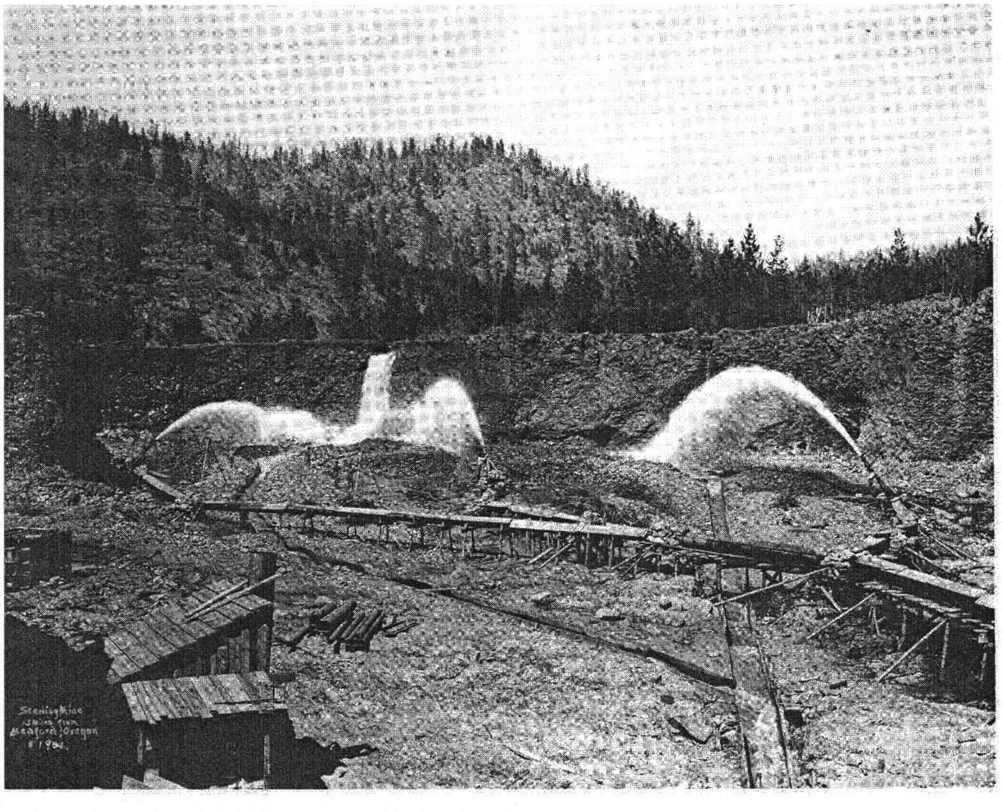
APPENDICES

Appendix A



A gold dredge, Sumpter, Oregon. (OHS)

Appendix B



Hydraulic gold mining near Medford. (OHS)

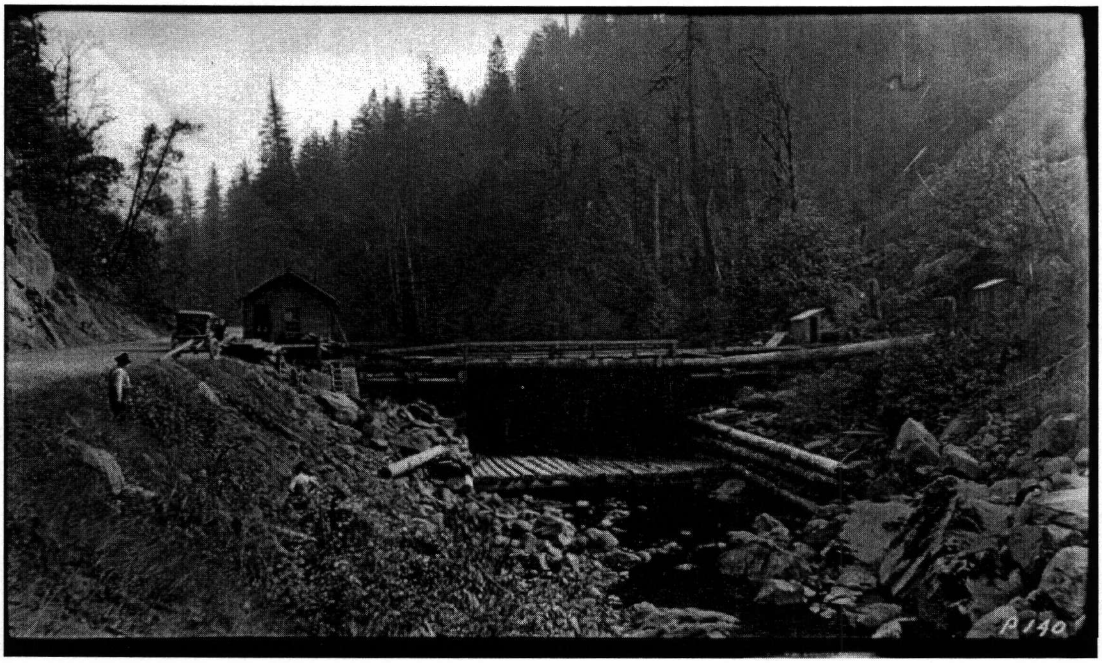
Appendix C

Logging on the Coquille River 1929. ("Courtesy of the port of Coquille." Middle Fork of the Coquille River Surveyed 1929. Picture 144 Sheet 17)

Appendix D

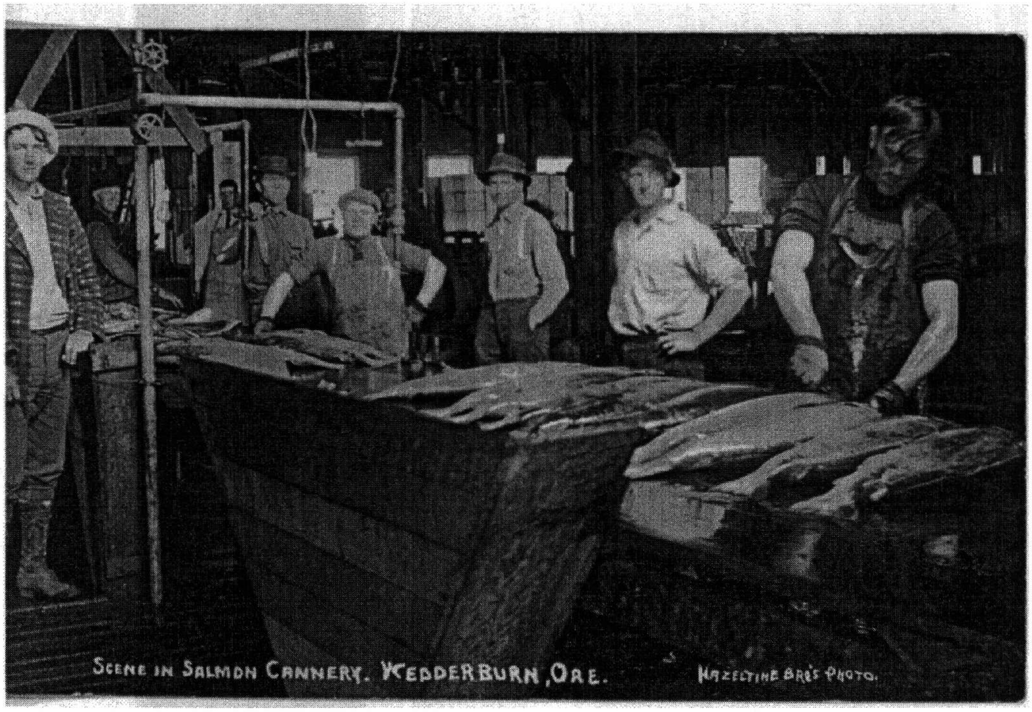
Logging on the Coquille River 1929. ("Courtesy of the port of Coquille." Middle Fork of the Coquille River Surveyed 1929. Picture 84 Sheet 10)

Appendix E



Splash Dam on the Coquille River, 1929. ("Courtesy of the port of Coquille." Middle Fork of the Coquille River Surveyed 1929. Picture 140 Sheet 16)

Appendix F

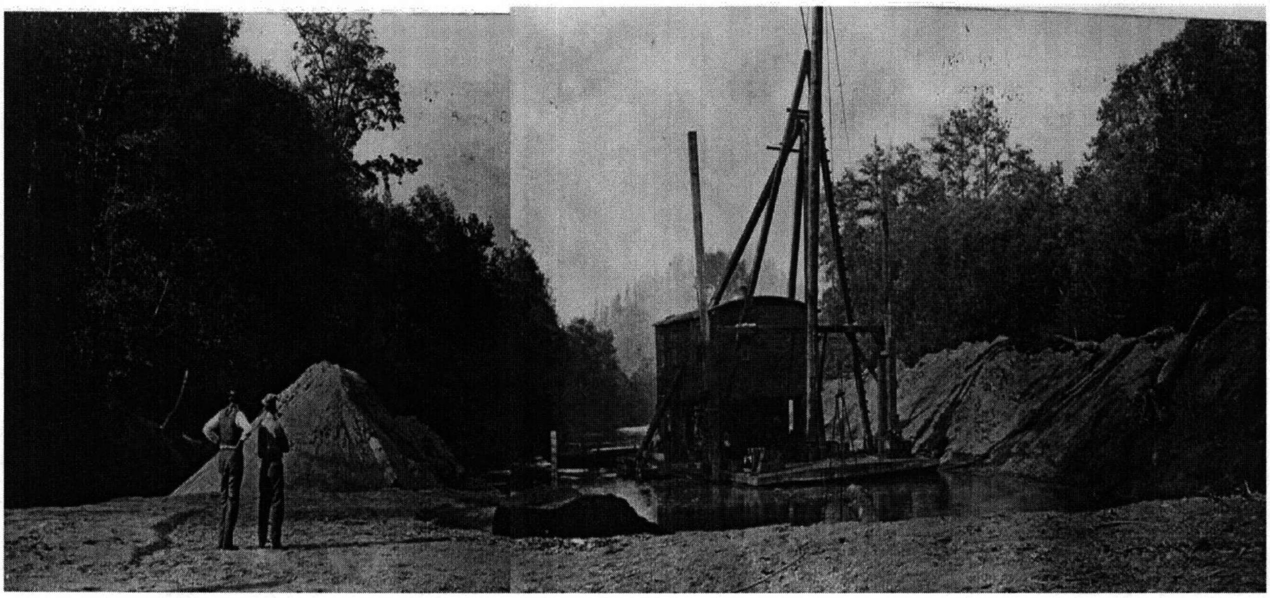


Kedderburn, OR. Salmon Cannery

Appendix G

Seining on the Rogue River, 1897

Appendix H



Dredging on the Coquille River, 1915. ("Courtesy of the port of Coquille.")