The Importance of Beaver (*Castor Canadensis*) to Coho Habitat and Trend in Beaver Abundance in the Oregon Coast Coho ESU

In 1997 the Oregon Plan for and Watersheds (OPSW) was initiated in an effort to reverse declining trends in coho salmon (*Oncorhynchus kisutch*) in Oregon coastal streams. The quality of freshwater habitat was one factor that was identified as potentially influencing the decline of coho in the ESU (OCSRI 1997). Pools formed by the dam building of beavers (*Castor canadensis*) may be an important component of high quality habitat for coho. This report reviews information on the importance of beaver to coho habitat and summarizes trends in beaver abundance for a State of Oregon assessment on the status and trend of coho and their habitat in the Oregon Coast Coho ESU (Figure 1).

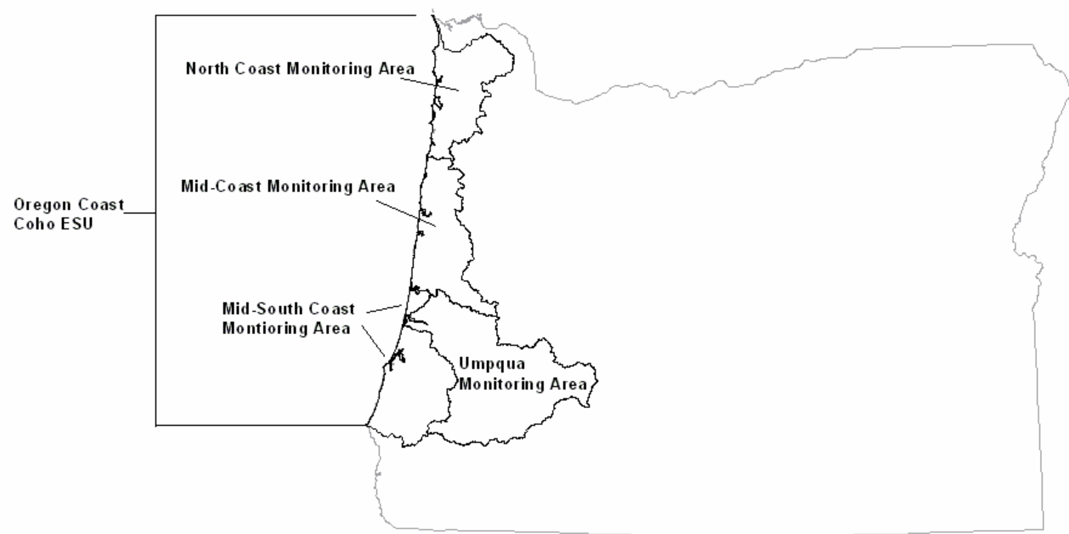

Figure 1. Location of four monitoring areas in the Oregon Coast Coho ESU. A GIS coverage of these monitoring areas my be obtained at:
ftp://nrimp.dfw.state.or.us/ORplan/ODFW/ODFW_72_DF_cstgca_nosc.zip

Ecosystem Effects of Beaver Dams

A distinct characteristic of beaver is their ability to alter their surrounding environment to better suit their needs through the building of dams. This ability to greatly modify the structure and dynamics of their surroundings has led beaver to be considered a “keystone species” (Naiman et al. 1986). Beaver dams have been shown to impact the hydrology, channel geomorphology, and water quality of streams and rivers.

Beaver prefer to dam streams that are low-gradient and in unconfined valleys. Geomorphic and hydrologic conditions such as gradient, stream depth, and stream width are good predictors of dam-site suitability (Beier and Barrett 1987). A study in the Drift Creek basin of the Oregon Coast Range found that 90% of beaver dams were located on streams with gradients of less than 6% (Suzuki and McComb 1998). Studies conducted in the states of Colorado and Washington also found a high percentage of total beaver dams located on low gradient streams with high valley widths (Pollock et al. 2003).

Beaver dams change the hydrology of streams in ways that are beneficial for many fish species, including juvenile coho. Water depth is increased and current velocity is decreased upstream of beaver dams. The impounded waters upstream of a beaver dam can have wetted surface areas that are orders of magnitude greater than the pre-existing stream channel (Naiman et al. 1986), and shorelines that are more complex than other natural ponds (Naiman et al. 1988). Other key hydrologic functions of beaver dams are to dissipate stream energy, attenuate peak flows, and increase groundwater recharge and retention which in turn will increase summer low flows and elevate groundwater levels (Pollock et al. 2003). During flood events, beaver dams dissipate energy by forcing water to either flow through a tortuous path of small branches on the downstream side of the dam or through floodplain vegetation as water works its way back to the stream channel (Woo and Waddington 1990). By slowing water velocities and increasing water depth and storage capacity, beaver dams can also moderate stream flow and through the retention of water, beaver dams can contribute to groundwater recharge and thus help to increase summer low flows (Pollock et al. 2003).

The slow water velocities created by beaver dams create large depositional areas that accumulate sediment and organic material (Pollock et al. 2003). Depending on climatic and geographic location, this sediment may persist and gradually fill the stream channel and valley with alluvial deposits, or it may be periodically washed downstream due to seasonal breaching of the dam (Talabere 2001). In the Oregon Coast Range, beaver dams on 3rd and 4th order streams tend to wash out during high winter flows and are rebuilt the following summer (Leidholt-Bruner et al. 1992). However, beaver dams have been noted during high winter flows on smaller streams, side channels, and adjacent wetlands in the Oregon Coast Range (Nickelson et al. 1992) and may persist through most winters. Beaver dams may also cause flooding of the adjacent valley floor, resulting in shallow waters that promote the growth of emergent vegetation and the addition of organic material to the system (Pollock et al. 2003). The extent of flooding depends on the valley form where the dam is located. Beaver ponds in upland V-shaped valleys tend to be small while ponds located in unconstrained floodplain areas can cover relatively large surface areas (Johnston and Naiman 1987).

The influence of beaver ponds on water temperature varies considerably depending on stream morphology and geographic location. McRae and Edwards (1994) found that in Wisconsin headwater streams, thermal effects of beaver dams depended on local differences in vegetative and topographic shading, groundwater inflow contribution, and flow volume.

Beaver Dams and Coho

Beaver dams can substantially alter stream hydraulics and create conditions that may benefit many fish species. Beaver ponds typically have slow current velocities and large edge-to-surface-area ratios, conditions that can provide extensive fish refugia and a productive environment for aquatic vegetation and benthic invertebrates. These factors can combine to provide fish with ample foraging opportunities requiring less energy to utilize. Thus, beaver ponds tend to be more productive than un-dammed stream reaches in terms of number and size of fish (Pollock et al. 2003).

Early observations of the impact of beaver dams on id species suggest detrimental effects due to increased siltation, elevated water temperatures, and impeded fish passage.

Research has shown these concerns to be unfounded, and no study has been able to demonstrate a detrimental population-level effect on ids. In fact, most studies support the contention that the habitat created by beaver dams is highly beneficial to fish and that many species are known to cross dams in both the upstream and downstream directions (Pollock et al. 2003).

Nickelson et al. (1992) studied habitat use by juvenile coho in 14 Oregon coastal streams during spring, summer, and winter seasons. They found that juvenile coho were most abundant in alcoves and beaver ponds during the winter. These habitat types made up only 31% of the area sampled during winter but accounted for 66% of coho sampled. In addition, beaver ponds supported more fish (mean = 456/pond) and higher densities of fish (1.28 fish/m^2) than other types of dammed pools (mean = 96/pool and density = 0.49 fish/m^2). Similarly, a study conducted on two coastal Oregon streams found coho densities in beaver ponds to be 0.34 coho/m^2, compared to densities in non-beaver pools of 0.26 coho/m^2 (Leidholt-Bruner et al. 1992).

Studies comparing the growth and survival of juvenile coho generally demonstrate that stream reaches above beaver dams produce more and larger fish than stream reaches where beaver dams are absent. In a study of summer habitat utilization in the Taku River of Southeast Alaska by Murphy et al. (1989), age 1+ coho were found to be most abundant in beaver ponds and upland sloughs. The mean fork lengths of coho found in beaver ponds were longer than those of coho found in other habitats, and the vast majority of larger coho were found in beaver pond habitat (Figure 2). Beaver ponds and tributary mouths only made up 2.2% of the total habitat area but accounted for 52% of the coho. Swales and Levings (1989) found beaver ponds to be major rearing areas for juvenile coho on the Coldwater River in British Columbia, Canada. Coho density estimates in ponds ranged from 0.1 to 1.0 coho/m^2 compared to density estimates in the main river of 0.08 to 0.23 coho/m^2. Coho also had a higher growth rate in ponds, with fish reaching mean lengths of 62 to 79 mm at the end of the first growing season, compared to 53 mm in the main river. In Carnation Creek, British Columbia, Bustard and Narver (1975) found the survival rate of coho in beaver ponds to be twice as high as the 35% estimated for the entire stream system.

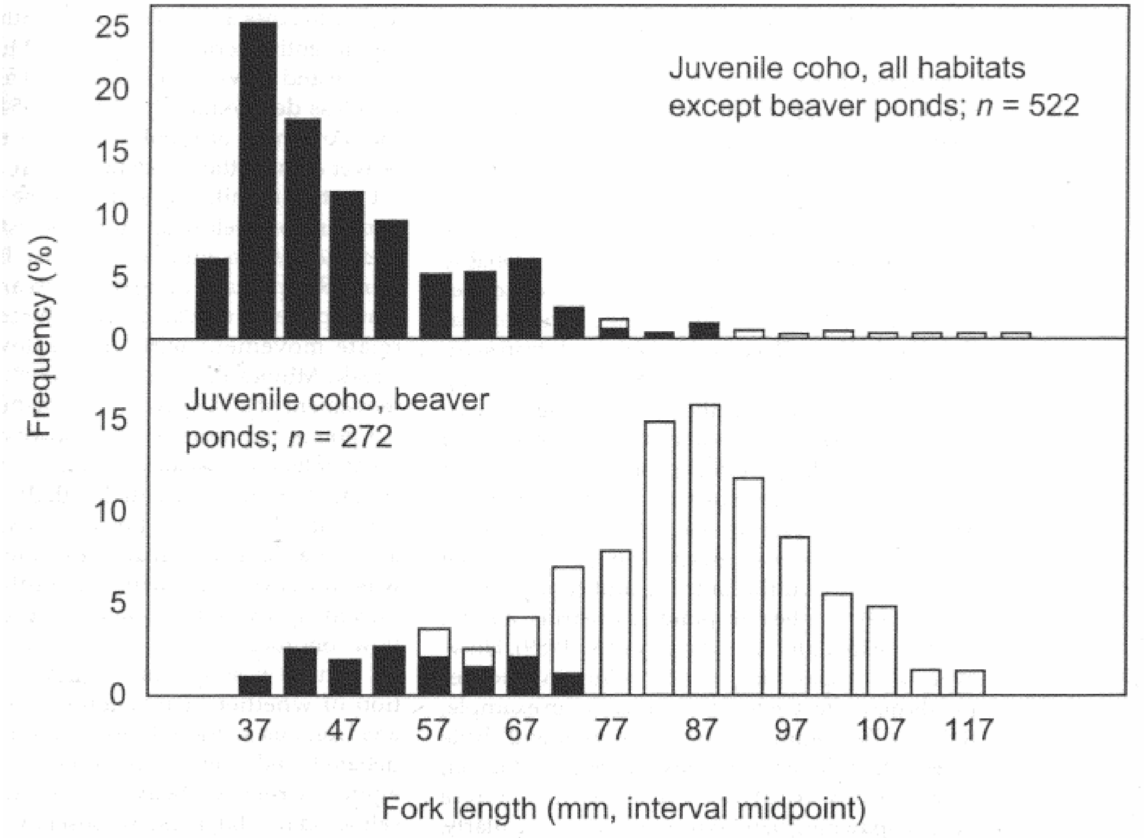

Figure 2. Size-frequency distribution of juvenile coho in the Taku River, southeast Alaska, showing that larger coho (age-1 light columns, age-0 dark columns) overwhelmingly prefer beaver ponds over any other habitat (adapted from Murphy et al. 1989).

The effects of widespread removal of beaver and their dams on coho were examined in the Stillaguamish River Basin of Washington by Pollock et al. (2004). Current and historic distributions of beaver ponds and other coho rearing habitats were assessed, and the greatest reduction in coho smolt production capacity was associated with the extensive loss of beaver ponds. Estimates of summer smolt production potential (SPP) have decreased from a historic level of 2.5 million smolts to 965,000 smolts currently, and winter SPP estimates have decreased from 7.1 million smolts historically to a current level of 971,000 smolts. For all habitat types, the greatest percent reductions in both summer and winter SPP are for beaver ponds (89% and 94% respectively). Historically, beaver pond habitat accounted for the majority of coho SPP (61% for summer and 86% for winter), while currently summer SPP is dominated by tributary habitats (62%) and winter SPP is mixed between beaver ponds, tributaries, and sloughs (38%, 27%, and 23% respectively) (Pollock et al. 2004).

<u>Historical Beaver Abundance in the Oregon Coast Coho ESU</u>

Prior to the arrival of Europeans in North America, beaver populations were estimated to be between 60 and 400 million individuals (Seton 1929). Extensive removal of beaver began in the early 17^{th} century in the Eastern United States, reducing populations dramatically. In the early 1800s, as eastern beaver populations declined, the fur trade moved west in search of new trapping areas. By 1900, continued trapping of beaver had left populations near extinction in North America (Naiman et al. 1988).

In the Pacific Northwest, the era of fur trading lasted approximately 60 years, from the 1780s to the 1840s. Beaver pelts became dominant in the Pacific Northwest fur trade around 1820 when sea otter populations declined. Production of beaver pelts by the Columbia Department of the Hudson Bay Company based in Astoria, Oregon, with territory throughout Oregon, Washington, and British Columbia peaked in 1833 at 28,949 pelts. By the 1840s the Northwest fur trade was clearly in decline and beaver populations were "…considerably reduced" between Fort Vancouver and northern California and "…nearly extinct, in the lower valley of the Columbia" (Rainbolt 1999). Guthrie and Sedell (1988) suggest that trapping in Oregon reduced an estimated one million beaver to remnant populations by the time of statehood in 1859. Beaver trapping was prohibited statewide in Oregon in 1899 and in 1932 a beaver relocation program was instigated. By 1951 beaver populations had rebuilt to levels were trapping for fur was allowed (Rainbolt 1999).

It is difficult to estimate historic beaver abundance in the Oregon Coast Range. The majority of information comes from the journals and diaries of early coastal explorers and fur-trappers. In a review of historic records, Rainbolt (1999) concludes that beavers were common in the Coast Range, but not abundant. Although fur-trappers reported much sign of beaver activity, trapping was difficult and initial forays along the Oregon coast resulted in disappointing harvests of pelts. It is Rainbolt's opinion that there would have been a greater trapping effort by the Hudson Bay Company if beaver abundances had been greater in the Coast Range, especially given that there was a policy of beaver eradication south of the Columbia River at the time. However, using the same historic accounts Guthrie and Sedell (1988) concluded that beaver, "…occurred in most streams along the Oregon coast, with teeming populations found even in tidewater." Dense, impenetrable forests, streams clogged with wood and impossible to navigate, and native tribes unused to hunting and trading beaver pelts all likely contributed to the lack of exploitation of beaver in the Coast Range. The regular occurrence of natural- and human-caused fire in the coast range may also have benefited beaver by opening up conifer dominated stream-sides to brushy invaders, which they preferred (Guthrie and Sedell 1988).

Studies by both Rainbolt (1999) and Guthrie and Sedell (1988) agree that beaver populations in the Coast Range were negligibly impacted by the fur-trapping companies, while beaver populations inland and throughout the Pacific Northwest were driven close to extinction. As a result, coastal streams and rivers probably contained large numbers of beaver ponds during the nineteenth century. These ponds, combined with high amounts of instream wood, provided id species with complex and varied habitat, including numerous marshes, side channels, and sloughs. A greater impact on coastal beaver populations may have been the extensive clearing, splash-damming, diking, and stream channelization that occurred in the early 1900s (Sedell and Luchessa 1982). These practices may have had a devastating impact on the diversity of habitat provided by instream wood and beaver ponds that is so beneficial to juvenile coho. Nickelson et al. (2002) report that only three of 14 Oregon coastal streams surveyed at winter base-flow had greater than 1% of their area in beaver pond or alcove habitat, and conclude that this lack of winter habitat limits the production of coho smolts.

Current Beaver Abundance in the Coastal Coho ESU

At the onset of the OPSW in 1997, the value of beaver dams to coho habitat was recognized and beaver management options that would benefit restoration were explored. The Oregon Department of Fish and Wildlife (ODFW) embarked on a non-regulatory, cooperative effort to increase public awareness and educate landowners and trappers of the benefits of beaver dams to coho habitat. As part of this effort, ODFW biologists began offering technical assistance and practicing management techniques to maintain existing beaver dams and encourage new beaver dam placement in areas critical to coho rearing. Telephone surveys of trappers harvesting beaver in coastal streams were conducted from 1999 to 2001. The trappers surveyed accounted for 93, 88, and 99 percent of the beaver harvested for each of the 3 years. For the entire 3-year period, 45 of the 3,663 beaver (1.2%) were harvested from areas identified as critical for coho rearing (2002 Oregon Fish and Wildlife Commission Report Packet).

In recent years, due to declining pelt prices, fewer beaver are being trapped solely for their pelts and most trappers participate in beaver trapping for reasons other than monetary profit. Statewide harvest levels of 10-11,000 beaver in the early 1980's have dropped by over 50%. According to ODFW harvest data, state-regulated beaver harvest in western Oregon has declined significantly from 1986 to 2003 (Figure 3). From 1986 to 1997, prior to the beginning of the OPSW, the average annual harvest of beaver from western Oregon was 4,239. Following the start of the OPSW, that number dropped to 2,612 beaver harvested annually. Until recently ODFW has been able to reliably track the harvest of beaver in Oregon because all individuals trapping beaver were required to obtain a trapping permit and report their harvest. In the future, however, monitoring beaver harvest will be more difficult because recent changes in state regulations allow beaver to be killed on private lands without the need for a permit (Personal communication on Nov. 18, 2004 with Doug Cottam, ODFW District Wildlife Biologist). In addition to ODFW, the Animal and Plant Health Inspection Service (APHIS) of the U.S. Department of Agriculture also carries out beaver elimination on the Oregon coast. For the entire state of Oregon from 1995 to 2004 this program has eliminated an average of ~700 beaver annually. At the time of this report, data specific to the coastal coho ESU was unavailable (Personal communication on April 13, 2005 with Jeff Brent, APHIS Regional Director).

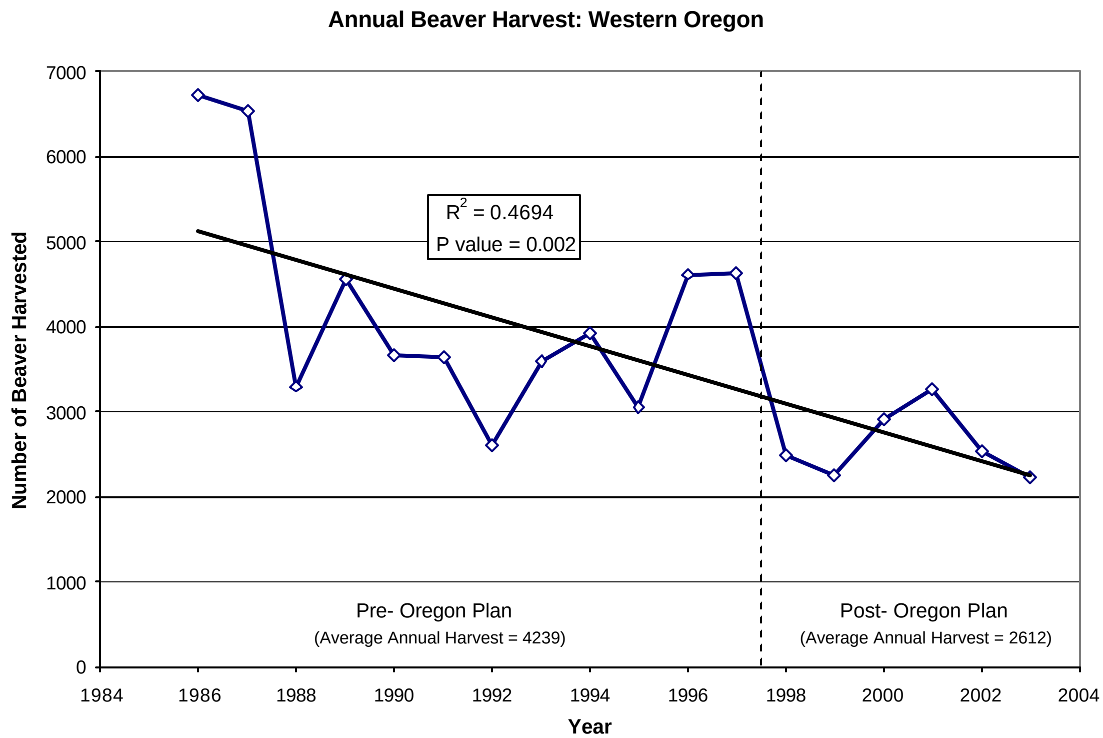

Figure 3. Beaver harvest for western Oregon from data compiled by the Oregon Department of Fish and Wildlife. Data in spreadsheet format available at ftp://nrimp.dfw.state.or.us/ORplan/ODFW/ODFW_142_DF_DataTable_Figure3_v1.xls

Yearly habitat data collected by ODFW shows no significant trend in the number of beaver ponds since the start of the OPSW, at either the ESU or the monitoring area spatial scales (Figure 3). At the ESU scale, percent of habitat surveys with beaver ponds is ranges between 10% and 20%, with the exception of 2001 at 27%. At the monitoring area scale, peaks in the percent of surveys with beaver ponds occur in different years, with the North Coast peaking at 44% in 2001, the Mid-Coast at 38% in 1998, and the Mid-South Coast at 33% in 1999. The Umpqua monitoring area stands out as having the lowest percentage of surveys with beaver ponds, with 0% in 3 out of the 6 years and greater than 10% only in 1999. Annual variability in the number of beaver ponds is high within the monitoring areas, with the North Coast increasing from 0% of habitat surveys containing beaver ponds in 1999 to over 40% in 2001, and annual differences of 20% fairly common in all monitoring areas except the Umpqua.

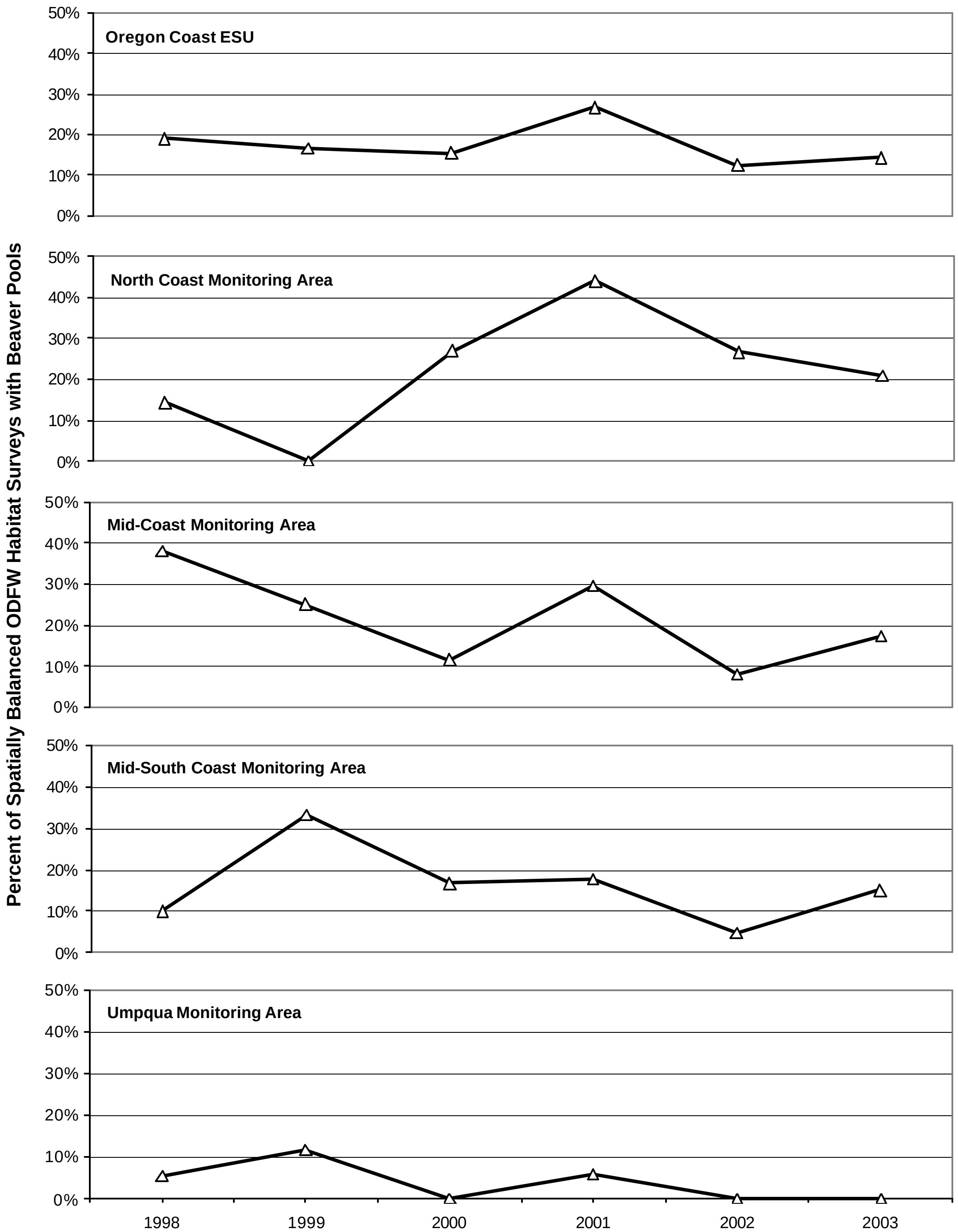

Figure 4. From 1998 to 2003, the percent of habitat surveys conducted by ODFW in the Oregon Coast Coho ESU that contain beaver pools, displayed for the ESU and individual monitoring area spatial scales. Data in spreadsheet format available at ftp://nrimp.dfw.state.or.us/ORplan/ODFW/ODFW_143_DF_DataTable_Figure4_v1.xls

Summary

Through the process of building dams, beavers can alter channel morphology and increase amounts of instream roughness, two parameters that are listed as Factors for Decline by the OPSW. Beaver dams create slow-water habitat favorable to rearing juvenile coho, and much of this habitat has been lost as a result of logging and agricultural practices following European settlement of the Oregon Coast. A 94% reduction in smolt production potential in a western Washington basin is attributed to the loss of beaver pond habitat. In a summary of 14 Oregon coastal streams surveyed at winter base-flow, only 3 had greater than 1% of their area in beaver pond or alcove habitat. This lack of winter habitat appears to be a limiting factor in the production of coho smolts.

At the onset of the OPSW in 1997, and in response to recognition of the benefit of beaver pond habitat to juvenile coho, ODFW began a voluntary program to discourage the trapping of beaver in critical coho habitat in Oregon coastal streams. Beaver harvest records suggest that the program has reduced the take of beavers in western Oregon. From 1986 to 1997, prior to the beginning of the OPSW, the average annual harvest of beaver from western Oregon was 4,239. Following the start of the OPSW, that number dropped to 2,612 beaver harvested annually. In addition, more detailed information on the harvest of licensed trappers from 1999-2001 found that only 45 of the 3,663 beaver harvested (1.2%) came from areas identified as critical for coho rearing. In the future, however, monitoring beaver harvest will be more difficult because recent changes in state regulations allow beaver to be killed on private lands without the need for a permit.

Although the harvest of beaver in the ESU appears to have declined, habitat surveys conducted in the Oregon Coast Coho ESU from 1997-2003 show high annual variability but no significant trend in the occurrence of beaver pools. Further research is needed to understand the relation between beaver harvest, beaver abundance, and high quality coho habitat.

References

Beier, P. and R.H. Barrett. 1987. Beaver habitat use and impact in Truckee River basin. California Journal of Wildlife Management 51:794-799.

Bustard, D.R. and D.W. Narver. 1975. Aspects of the winter ecology of juvenile coho (*Oncorhynchus kisutch*) and steelhead trout (*Salmo gairdneri*). Journal of the Fisheries Research Board of Canada 32:667-680.

Guthrie, D. and J. Sedell. 1988. Primeval beaver stumped Oregon Coast trappers. Pages 14-16 *in* News & Views. Department of Fisheries and Wildlife, Oregon State University.

Johnston, C.A. and R.J. Naiman. 1987. Boundary dynamics at the aquatic-terrestrial interface: The influence of beaver and geomorphology. Landscape Ecology 1:47-57.

Leidholt-Bruner, K., D.E. Hibbs, and W.C. McComb. 1992. Beaver dam locations and their effects on distribution and abundance of coho fry in two coastal Oregon streams. Northwest Science 66:218-223.

McRae, G., and C.J. Edwards. 1994. Thermal characteristics of Wisconsin headwater streams occupied by beaver: implication for brook trout habitat. Transactions of the American Fisheries Society 123:641-656.

Murphy, M.L., J. Heifetz, J.F. Thedinga, S.W. Johnson, and K.V. Koski. 1989. Habitat utilization by juvenile Pacific salmon (*Oncorhynchus*) in the glacial Taku River, southeast Alaska. Canadian Journal of Fisheries and Aquatic Sciences 46:1677-1685.

Naiman, R.J., C.A. Johnston, and J.C. Kelley. 1988. Alteration of North American streams by beaver. BioScience 38:753-762.

Naiman, R.J., J.M. Melillo, and J.E. Hobbie. 1986. Ecosystem alteration of boreal forest streams by beaver (*Castor canadensis*). Ecology 67:1254-69.

Nickelson, T.E., J.D. Rodgers, S.L. Johnson, and M.F. Solazzi. 1992. Seasonal changes in habitat use by juvenile coho (*Oncorhynchus kisutch*) in Oregon coastal streams. Canadian Journal of Fisheries and Aquatic Sciences 49:783-789.

Oregon Coastal Salmon Restoration Initiative (OCSRI). 1997. The Oregon Plan: Oregon's Coastal Salmon Restoration Initiative. Salem, Oregon.

Pollock, M.M., M. Heim, and R.J. Naiman. 2003. Hydrologic and geomorphic effects of beaver dams and their influence on fishes. Pages 213-234 *in* S.V. Gregory, K. Boyer, and A. Gurnell, editors. The ecology and management of wood in world rivers. American Fisheries Society, Bethesda, Maryland.

Pollock, M.M., G.R. Pess, T.J. Beechie, and D.R. Montgomery. 2004. The importance of beaver ponds to coho production in the Stillaguamish River basin, Washington, USA. North American Journal of Fisheries Management 24:749-760.

Rainbolt, R.E. 1999. Historic beaver populations in the Oregon Coast Range. Oregon Department of Fish and Wildlife, Salem, Oregon.

Sedell, J.R. and K.L. Luchessa. 1982. Using the historical record as an aid to ID habitat enhancement. American Fisheries Society, Bethesda, MA. pp. 210-223.

Seton, J.R. 1929. Lives of game animals. Vol. 4, Part 2, Rodents, etc. Doubleday, Doran, Garden City, NY.

Suzuki, N. and W.C. McComb. 1998. Habitat classification models for beaver (*Castor canadensis*) in the streams of the central Oregon Coast Range. Northwest Science 72:102-110.

Swales, S. and C.D. Levings. 1989. Role of off-channel ponds in the life cycle of coho (*Oncorhynchus kisutch*) and other juvenile ids in the Coldwater River, British Columbia. Canadian Journal of Fisheries and Aquatic Sciences 46:232-242.

Talabere, A. 2001. The effects of beaver dams on aquatic ecosystems with special attention to salmon and trout in the Pacific Northwest, USA. Final Report to the Oregon Wildlife Heritage Foundation. Oregon Department of Fish and Wildlife, Salem.

Woo, M. and J.M. Waddington. 1990. Effects of beaver dams on subarctic wetland hydrology. Arctic 43:223-230.