INTRODUCTION

This report was funded by the "Puget Sound and Coastal Washington Hatchery Reform Project." The goals of the hatchery reform project are to "conserve indigenous genetic resources, assist with the recovery of naturally spawning populations, provide for sustainable fisheries, conduct scientific research, and improve the quality and cost-effectiveness of hatchery programs" (Gorton Science Advisory Team 1999).

This report presents options and recommendations regarding anadromous fish use of the habitat above the Quilcene National Fish Hatchery (NFH) in the Big Quilcene River. Quilcene NFH presently blocks anadromous fish access to about 3.2 miles of mainstem river. Restoration of anadromous fish access to this reach of the Big Quilcene River is consistent with the goals of the hatchery reform project.

This work also supports several goals of the U.S. Fish and Wildlife Service (FWS). The FWS adopted an ecosystem approach to resource management several years ago. Teams were established within the North Pacific Coast Ecoregion to discuss and identify ecosystem concerns and possible corrective actions for implementation. Salmon use of stream habitat above human-caused impasses (fish hatchery weirs, for example), surfaced as a priority concern during a North Pacific Coast Ecoregion meeting in August of 1999.

Fish passage improvement has also been identified as a priority effort within the work activity guidance in the FWS Region l Fisheries Program (Diggs 2000). The program guidance specifically states that, "Where we have created impediments to fish passage, we must remove them."

In addition to the Region 1 program, a national "Fish Passage Program" is being developed (FWS 2000). The national program goal is to "Restore native fish and other aquatic species to self-sustaining levels by reconnecting historical habitats and re-establishing watershed function through removal of, or passage around manmade barriers."

While the topic of habitat use above our National Fish Hatcheries is currently receiving regional and national attention, it is not a new subject for the Quilcene NFH Hatchery Evaluation Team. This team consists of FWS staff from Quilcene NFH, the Olympia Fish Health Center, and the Western Washington Office. The team continues to discuss and direct hatchery operations, including use of stream habitat above the hatchery.

We will not address salmon restoration in Penny Creek, which serves as the nursery's water source, in this report. Rather, an ad-hoc committee will address Penny Creek and may propose a feasibility study. Disease risk and cost of facility modification may prohibit consideration of restoring salmon to Penny Creek. This report also assumes no changes to current hatchery production with recommendations discussed herein, because of management constraints described in this report.

OBJECTIVES OF RESTORED SALMON USE

One objective of restoring salmon use to streams is to optimize fish production from the freshwater environment. Historically, this effort was directed primarily toward hatchery programs that were initiated to mitigate for declining wild populations and lost harvest opportunities. Ironically, in many cases this caused a further decline in wild populations since they could not be separated from abundant hatchery stocks in the harvest areas and were subsequently over-harvested. Recently, listings of several populations of salmon under the Endangered Species Act have resulted in closed fisheries or changes in harvest methods. These changes are designed to allow weak populations access to freshwater habitats for spawning. In streams where wild populations are not threatened by hatchery stocks, making additional freshwater habitat available to salmon, may result in increased salmon production and subsequent increased contributions to commercial and sport fisheries.

Another objective is to restore some level of "natural selection" pressures by allowing anadromous fish to use the available habitat. In the process of evolution, natural selective forces have chosen the combination of traits that will best enable organisms to survive in their natural environment. These traits may or may not be apparent to us, but we know that unique combinations of genes develop in response to specific environmental influences (Hershberger and Iwamoto 1983). Some scientists believe that hatchery fish have been genetically altered as a result of many years of human selection of matings, stocks, run timing, and other fish cultural practices (Reisenbichler and Rubin 1999). These authors argue that artificial propagation results in significant genetic change which lowers fitness. Fitness in this case refers to the ability to naturally propagate.

A third objective is to enhance stream productivity through nutrient enrichment. As carcasses decompose, they provide a significant amount of the nutrients that are incorporated into the stream food web (Kline *et al.* 1990; Bilby *et al.* 1996). Carcasses are also a direct food source for juvenile salmonids. Also, many salmonid carcasses are hauled out of streams for consumption by terrestrial animals and subsequent nutrient cycling through the terrestrial system (Cedarholm *et al.* 2000).

PROGRAM MANAGEMENT

The Quilcene NFH is located at river mile (RM) 2.8, at the confluence of Penny Creek on the Big Quilcene River which empties into Hood Canal (Figure 1). The Quilcene NFH was established in 1912 "...for the propagation of salmon and other food fishes..." on Puget Sound.

The current fish production program at Quilcene NFH is consistent with the Puget Sound Salmon Management Plan (1985), the Hood Canal Salmon Management Plan (Point No Point Treaty Council (PNPTC) *et al.* 1986), the Hood Canal Production Evaluation Program (PNPTC *et al.* 1989), and the Summer Chum Conservation Initiative (Washington Department of Fish and Wildlife (WDFW) and Point No Point Treaty Tribes 2000). Modifications to the fish production program are discussed as needed with PNPTC (representing the S'Klallam Tribes), the Skokomish Tribe, and the WDFW. Agreement by the parties is required before a change in production can be implemented, as required by the aforementioned plans and management agreements.

Each year's proposed fish production program is further coordinated with the State and Tribal co-managers through the annual Future Brood Document process that includes all Washington hatcheries. This process was originally initiated as a result of the Boldt decision and the court order for the co-managers to communicate fish production activities (Andy Appleby, WDFW, per. comm., 2000). The current production program includes releases of 2.2 million fall chum, 389,000 summer chum, and 450,000 coho yearlings into the Big Quilcene River. The hatchery also transfers 200,000 coho yearlings to Quilcene Bay net pens (operated by the Skokomish Tribe), 450,000 coho eggs to George Adams Hatchery (WDFW), and 104,000 summer chum eggs to Big Beef Creek research facility. The overall production program, including species and numbers produced, has remained fairly stable since the inception of the summer chum program in 1992. However, the summer chum production will be downsized as the population increases or we reach the end of the proposed term of the program in 2003.

Hatchery and Genetic Management Plans describing our production, purposes, and methods have been submitted to National Marine Fisheries Service (NMFS) for consultation, which is required under the Endangered Species Act. The Biological Opinion has been drafted by NMFS staff, discussed with FWS staff, and is currently being reviewed by NMFS administration.

PREVIOUS PASSAGE PROGRAM

Before 1984, approximately 800 adult coho salmon were actively passed each year above the "old" Quilcene NFH weir to spawn in the Big Quilcene River. This required multiple handling of the adults, from holding ponds to trucks and finally back to the stream, which caused major scale loss and associated stress on both fish and staff. This weir consisted of multiple electrical probes suspended from an overhead line. When the probes came in contact with the water an electrical barrier was formed which forced returning salmon to enter the hatchery ladder. Typically, chum salmon were not passed and the occasional steelhead and cutthroat trout were returned to the river during weir operation. No observations of bull trout/Dolly Varden during weir operation have been found during a recent review of historic and recent hatchery records.

The program was finally changed in 1991, from adult passage to fingerling stocking of 25,000 coho salmon annually, although adult fish could move freely when the weir was not electrified between January and April. This change was implemented to reduce the risk of pathogen transfer from adult passage. Carcasses lodged on the water intake grate may have exposed the

juveniles to pathogens via the hatchery water supply. Difficulties in handling adults, as described above, also prompted the change to fingerling outplants.

CURRENT PROGRAM

The "new" weir, built in 1990, acts as a physical block to upstream movement during low flows which occur from about June to late October (Figure 1). The weir is electrified as flows increase beginning about November 1 and de-activated about January 1. The new weir's electrodes are incorporated into the structure's base and create a graduated electrical current related to water depth. It was constructed with a ladder to allow upstream fish passage. However, high flow events, and associated stream bed and channel movement, have rendered the ladder inoperable. The upstream end of the ladder is now totally blocked by accumulated gravel. Work to correct the problem is scheduled for late summer of 2002, pending permit acquisition.

Currently, we do not pass coho or chum salmon. The occasional steelhead or cutthroat trout is passed. In lieu of passing adult salmon, we outplant approximately 25,000 specific pathogen inspected fingerling coho salmon each spring in the accessible reach of the river just above the hatchery. However, fish can move freely, up to about RM 6 (Figure 1), when the weir is not operational between January and June and during power outages in the fall and early winter. The hatchery intake structure located at RM 3.3 (Figure 1) is a minor impediment that is fitted with a bypass ladder that allows upstream migration.

FISH HEALTH ISSUES

Returning adult fish may harbor large numbers of pathogens that are released into the environment with the eggs and fluids during spawning and from the carcasses during decomposition. This is probably the most significant period of pathogen transmission. A second period of high pathogen release may occur during hatching and emergence of the fry. If these activities occur above the water intake, infectious agents may be showered onto the juvenile fish in the hatchery. Relative risk depends on pathogen density, susceptibility of the hatchery fish to specific pathogens, and stream flow.

With low numbers of pathogens occurring in the water supply, control measures may be used within the hatchery to minimize the impact on the juvenile fish, frequently without the use of drugs and chemicals. Measures could include reduced rearing densities, pond manipulations, more frequent carcass removal from intake grates, or changing water withdrawal between the two intakes. Maintaining a healthy fish population inside the hatchery with minimal use of drugs and chemicals is expected to have the least impact on aquatic populations downstream from the hatchery. If there is a large, highly infected spawning population above the hatchery intake, juvenile fish losses may result even with the best management practices and with heavy use of approved drugs and chemicals.

Pathogens of concern in the Big Quilcene River include *Renibacterium salmoninarum* (bacterial

kidney disease), *Aeromonas salmonicida* (furunculosis), *Flavobacter psychrophilum* (bacterial coldwater disease), and *Infectious Hematopoietic Necrosis Virus* (IHN). These pathogens have all been isolated from broodstock at the hatchery during broodstock inspection testing. However, the only pathogens on this list isolated from juvenile fish in Quilcene NFH are *R. salmoninarum* and *F. psychrophilum.*

Potential disease problems caused by passing infected adults upstream of the hatchery's water supply were noted as a major concern in the past. The evolution of our upstream program from adult passage to fingerling releases was shaped, in part, because of that concern. While the disease concern still persists, fish health biologists realize that suitable habitat should be used for natural fish production but may recommend modifications to fish hatchery operations to minimize the disease risk if an adult passage program is initiated.

HABITAT and SALMONID FISH USE

The Big Quilcene River originates on the eastern slopes of the Olympic Mountains within the Buckhorn Wilderness Area of the Olympic National Forest. The U.S. Forest Service (USFS) eastern boundary is located at RM 4. The lowest 4 miles of the river are privately owned (USFS 1992) except at the Quilcene NFH itself (Figure 1).

The mainstem length is 18.9 miles. There are also 81.9 miles of tributaries entering the Big Quilcene River. However, no tributaries are accessible to anadromous fish (WDFW 1975). There is a natural impasse (falls) at RM 7.6 that is 15 to 20 feet tall. But, it is doubtful that fish can ascend this far due to the cumulative effect of numerous cascades and rapids between RM 5 and RM 6 (WDFW 1975; Zajac 1989)(Views 1 and 2). These cascades are the upper limit to anadromous fish migration (Figure 1).

The City of Port Townsend operates a water diversion structure at RM 9 (Figure 1) and has rights to 30 cubic feet per second (cfs). Monthly average flows as measured just below the diversion from 1993 to 1999 ranged from a low mean of 37 cfs in September to a high mean of 250 cfs in December. The City's average withdrawal is 24 cfs. However, during low flow periods, the City reduces withdrawals to allow at least 27 cfs in the river at their diversion per verbal arrangement with the FWS (Jablonski 2000). The diverted water is used for the City's municipal and industrial needs and to supply water to the Port Townsend Paper Company. The Quilcene NFH has a water right of 40 cfs which is conditional with respect to low flow and bypass reach requirements. Their right is guaranteed at a minimum of 15 cfs for fish production purposes.

Generally, habitat quality of the Big Quilcene River is poor, especially below RM 1. Specifically, this reach lacks pools, cover, woody debris, side channels, tributaries, and stable substrate. The river is degraded due to water withdrawal, low channel complexity, sub-estuarine modifications (diking), sediment accumulation, and a young deciduous-dominated riparian forest (WDFW and PNPTC 2000). This reach has also been armored and channelized.

The section of river of concern above the hatchery lies between RM 2.8 (hatchery) and approximately RM 6 where numerous cascades prevent fish passage. The habitat between RM 2.8 and RM 6 is of mediocre quality (Zajac 1989). Suitable spawning gravel is limited to the section between RM 2.8 and RM 3.2. The section between RM 3.2 and RM 6 is characterized by large rock and boulders as seen in Views 3-5. Also, over-winter rearing habitat consisting of side channels and tributaries is lacking.

In 1992, the USFS conducted a survey of the Big Quilcene River during low flow condition in August and September. The USFS (1992) reported that the stream gradient ranged from an average of 1% in the lowest part of this section to an average gradient of 3% in the upper part of the section. They also reported dominant substrate size as gravel (0.2 cm-6.4 cm) and cobble (6.4 cm-25.6 cm) in the lower areas, and cobble and small boulder (25.6 cm-102.4 cm) in the upper area. The USFS (1992) estimated a riffle/glide-to-pool ratio of about 75% to 25% and suggested that a desired target ratio of 50% could be achieved by adding large woody debris. Only 18 pieces of large woody debris (36-inch diameter by 50-foot length) were counted compared to a suggested goal of more than 300 pieces. They reported riparian vegetation as heavy and predominantly Douglas fir and western red cedar. Stand age on the USFS land in this section is 140 years and older (Marc McHenry, USFS, per. comm., 2000). However, the USFS also found that the overall canopy cover is less than 20% for most of the section compared to a goal of 60%. FWS staff made several site visits to this section in September 2000, and although no specific measurements were taken, visual observations support the USFS findings.

However, specific segments of the upper river are in good condition. The USFS reported that the section between RM 9 and RM 10.6 is “very diverse and ecologically sound” (USFS 1992). Water temperatures, as reported at the hatchery from 1983-1993, are good for salmonid production and range from a low mean of 39.6 F (4.2 C) in January to a high mean of 54.4 F (12.4 C) in August.

Currently, coho, pink, and summer and fall chum salmon, steelhead, and cutthroat trout use the Big Quilcene River below the Quilcene NFH. Two observations of bull trout/Dolly Varden were reported by Mongillo (1993) downstream of the hatchery. However, the Big Quilcene River is not considered bull trout/Dolly Varden habitat (Paul Mongillo, WDFW, per. comm., 2000). The river between the hatchery and the impassible falls at RM 7.6 is used by rainbow trout, steelhead, and cutthroat trout that are passed intentionally, and a few coho and chum salmon that escape past the hatchery electrical weir during infrequent power outages and high water caused by storm events. The upper reaches of the Big Quilcene River are inhabited by rainbow and brook trout.

Limited sampling suggests that there is production potential in the section of river above the hatchery. During weir construction in 1990, numerous juvenile coho were netted from pools in the project area above the weir and released downstream. Coho fry were also captured above the hatchery in 1998, during National Wild Fish Health surveys, indicating that adults that moved upstream during high flow events spawned successfully. Also, adult coho mark-return ratios may indicate that some production is being realized from either the fry plants or from adults successfully spawning upstream (Kane 1996).

Many agencies are currently addressing habitat deficiencies in the Big Quilcene River watershed. Active habitat improvements include residential land acquisition and dike setbacks in the lower river (Al Latham, Jefferson County, per. comm., 2000). Gravel traps are installed in the lower river, when funding is available (Ken Cook, Jefferson County, per. comm., 2000), to reduce flooding impacts to land owners and to reduce gravel aggradation in spawning areas. The USFS has obliterated logging roads in the past and added woody debris structures in some sections of the upper watershed (Marc McHenry, USFS, per. comm., 2000). Passive habitat improvement is being implemented by the USFS, since they have identified most of the watershed as "Late Successional Reserve". This action is primarily aimed at promoting old-growth development by eliminating timber harvest after the stands reach the age of 80. Younger stands may be thinned. However, no work is scheduled in the near term (Marc McHenry, USFS, per. comm., 2000).

A parallel effort directed towards establishing instream flows in the Big Quilcene River under the "Chelan Agreement" and the Department of Ecology is in progress. The Chelan Agreement was developed in November of 1990 (during a retreat at Lake Chelan) and is intended to allow/promote water users to jointly resolve water management conflicts and develop water management plans. A Planning Unit, consisting of local stakeholders and resource agencies, as well as an associated steering committee and technical committee, has retained a consultant to review data and literature, and summarize findings regarding surface water quality, quantity, and flow, groundwater quality, and fish habitat. The final report was completed in October 2000. The report includes all watersheds in the Water Resource Inventory Area 17. The FWS is participating in this process.

OPTIONS

Following are three options that could be considered, either individually or in combinations, regarding salmonid use of the habitat above Quilcene NFH: 1) adult passage, 2) juvenile planting, or, 3) adult carcass distribution for stream/nutrient enhancement purposes. All three options are directed towards the section of river between the hatchery at RM 2.8 and the impassable areas near RM 6. The river downstream of the hatchery is already being used by coho, chum, pink, and chinook salmon, steelhead, and cutthroat trout. Areas upstream of the anadromous impasses (especially the falls at RM 7.6) have been reserved for resident trout, following an earlier informal verbal agreement with USFS fisheries staff. Salmon and trout releases above the falls were discontinued by WDFW and FWS, and the fishery is limited to catch and release for resident trout.
The three options for the target reach are discussed in further detail below.

Option 1: Adult Passage. The advantage of renewing an adult passage program is that all project objectives could be accomplished. Additional freshwater salmon production could contribute to all fisheries. Mate selection and subsequent juvenile survival would experience "natural selection pressures." Spent carcasses would contribute to the ecology of the stream by providing flesh for aquatic and terrestrial organisms and nutrients to the system during decomposition. Also, no human handling would be required to move fish into the habitat. The fish would voluntarily ascend the weir bypass ladder.

Potential negative impacts from an adult passage program may include complaints from surrounding land owners about the odor of decaying carcasses. However, several land owners have generally indicated that they would like "to see big fish" upstream of the hatchery (Ron Wong, FWS, per. comm., 2000). Also, there is some risk associated with infected adults shedding pathogens into the hatchery water supply. Although not expected, it is possible that an adult passage program could affect a population of rainbow trout that exists above the hatchery. This population may have originated from a WDFW stocking program that was discontinued in the mid 1990s.

Coho salmon are the preferred species in this option. A production parameter of 1.12 smolts produced per linear meter of stream (Baranski 1989) and a factor of 50 smolts produced per female (Tim Flint, WDF, per. comm.,1989) may be used to calculate the minimum number of adults to pass. In 1994, the Hood Canal Joint Technical Committee developed escapement goals for the Big Quilcene River using parameters of 2.5 smolts produced per linear yard (or 2.734 per linear meter)(Lister and Walker 1966) and a factor of 23.52 smolts produced per spawner (or 47.04 smolts per female). The two sets of parameters can be used to calculate a range of appropriate adult coho passage numbers. Chum salmon are not proposed, as this species typically prefers lower river areas. Also, Quilcene chum salmon adults have been found to carry infectious hematopoietic necrosis virus. Exposing juvenile hatchery fish to this virus could compromise production.

Option 2: Juvenile Planting. The only advantage in considering this option is the ability to plant specific pathogen-inspected fingerlings and minimize fish health concerns that arise in an adult passage program. It would satisfy the objectives of increasing production and imposing natural selection pressures. The objective of enhancing stream productivity through nutrient enhancement would not be accomplished.
However, access points to stocking locations are limited, and distribution at appropriate densities throughout the reach may not be achieved. Again, this program may impact the rainbow trout population.

Coho salmon are also the preferred species in this option. We have submitted documents to NMFS for consultation purposes regarding hatchery operation

impacts to federally listed, threatened summer chum salmon. NMFS has required that we discontinue our upstream coho salmon fingerling releases. In their draft Biological Opinion, NMFS believes that coho salmon fry plants may reside and consume summer chum salmon fry (Tim Tynan, NMFS, per. comm., 2000).

Option 3: Carcass Distribution. Carcass distribution would meet the objective of enhancing stream productivity and providing another food source to the ecosystem. It would not, however, meet the objectives of actually using the habitat for fish production. This option would be logistically difficult to accomplish with respect to carcass distribution, WDFW permit acquisition, and its associated signage and carcass identification requirements. Carcasses are marked so that they are not incorporated into spawn ground surveys and escapement estimation. Surrounding land owners may complain about the odor of decaying carcasses. This option is not advantageous when compared to Options 1 and 2.

In this option, only carcasses the OFHC considered the lowest fish health risk would be used. Risk would be based on historical inspection records, as well as in-season sampling of 100% of the carcasses distributed.

DISCUSSION and RECOMMENDATION

We recommend pursuing Option 1, as it meets all three stated objectives, pending maintenance to remove gravel that has rendered the bypass ladder inoperable. Based on the parameters discussed in Option 1 between 230 and 599 coho salmon from throughout the return should be allowed to ascend the bypass ladder. The sex ratio should be 50/50 and 4 % of the males should be 2-year olds (jacks), as recommended by Seidel (1983). Incorporation of jacks into the spawning population ensures that genetic material from across broods will be contributed to the offspring. However, FWS pathologists may recommend reducing or eliminating a passage program in-season if a “Regulated or Reportable Pathogen”, as listed in the Salmonid Disease Control Policy of the Fisheries Co-managers of Washington State, is isolated during routine sampling of returning adults. Also, passage may be stopped upon finding a non-endemic pathogen that would pose a significant threat to juvenile hatchery fish, as well as other fish populations in the watershed, as determined by Olympia Fish Health Center staff.

This program will not be exercised at the expense of hatchery production needs, commercial and sport harvest opportunities, nor the current carcass distribution program to the Skokomish Tribe . We currently distribute carcasses that are fit for human consumption to the Skokomish Tribe via a cooperative agreement with the Bureau of Indian Affairs. Typically, more fish return than are needed for hatchery production purposes, can be effectively harvested, or are distributed for human consumption.

Co-manager Contact

The WDFW area biologist (Thom Johnson, per. comm., 2000) and PNPTC staff (Chris Weller,

per. comm., 2000) have tentatively concurred with resuming adult coho salmon passage. Also, NMFS will probably agree to a co-manager supported adult passage program (Tim Tynan, NMFS, per. comm., 2000). We also anticipate a "no effect" determination from our internal section 7 consultation regarding impacts to bull trout with this option.

These preliminary discussions were held to ensure that our internal recommendation was attainable and that WDFW, PNPTC, and NMFS would likely support the program. The discussion was not framed as a final proposal. Rather, it was approached as a theoretical possibility pending completion of this report and final concurrence from the agencies.

Program Evaluation

No specific program evaluation is proposed in the short-term. However, as time and funding permit, we should evaluate the resulting smolt production and subsequent adult return from restored adult passage.

An indication of program success may be realized through our coded-wire tagging and mass marking of hatchery production. Returning ratios of marked-to-unmarked fish may provide information on natural production associated with resumed adult passage.

REFERENCES

luction in Ten Puget Sound Streams. Washington Department of Fisheries, Olympia, Washington.

Bilby, R.E., B.R. Fransen, and P.A. Bisson. 1996. Incorporation of nitrogen and carbon from spawning coho salmon into the trophic system of small streams: evidence from stable isotopes. Canadian Journal of Fisheries and Aquatic Sciences 53:164-173.

Cedarholm, C.J., D.H. Johnson, R.E. Bilby, L.G. Dominguez, A.M. Garrett, W.H. Graeber, E.L. Greda, M.D. Kunze, B.G. Marcot, J.F. Palmisano, R.W. Plontnikoff, W.G. Pearcy, C.A. Simenstad, and P.C. Trotter. 2000. Pacific Salmon and Wildlife-Ecological Contexts, Relationships, and Implications for Management. Special Edition Technical Report, Prepared for D.H. Johnson and T.A. O'Neil (Manag. Dirs.), Wildlife-Habitat Relationships in Oregon and Washington. Washington Department of Fish and Wildlife, Olympia, Washington.

Diggs, Daniel. 2000. Fisheries Work Activity Guidance. Memorandum dated June 27, 2000 to Region 1 Fisheries Project Leaders. U. S. Fish and Wildlife Service, Portland, Oregon.

Gorton Science Advisory Team. 1999. The Reform of Salmon and Steelhead Hatcheries in Puget Sound and Coastal Washington to Recover Natural Stocks While Providing Fisheries. Olympia, Washington.

Hershberger, W.K. and R. N. Iwamoto. 1983. Genetics Manual and Guidelines for the Pacific Salmon Hatcheries of Washington. University of Washington. Seattle, Washington.

Jablonski, I. 2000. Big Quilcene River and Little Quilcene River Flow and Summer Chum History (Draft). City of Port Townsend, Port Townsend, Washington.

Kane, T. 1996. Broodyear Report for Olympic Peninsula National Fish Hatcheries: Broods Completed in 1994-95. U. S. Fish and Wildlife Service, Western Washington Fishery Resource Office, Olympia, Washington.

Kline, T.C., Jr., J.J. Goering, O.A. Mathisen, P.H. Poe, and P.L. Parker. 1990. Recycling of elements upstream by runs of Pacific salmon: I. D15N and d13C evidence in Sashin Creek, southeastern Alaska. Canadian Journal of Fisheries and Aquatic Sciences 47:136-144.

Lister, D. B. and C. E. Walker. 1966. The of flow control on freshwater survival of chum, coho, and chinook salmon in the Big Qualicum River. Canadian Fish Culturist Vol. 37, pp 3-25.

Mongillo, P.E. 1993. The Distribution and Status of Bull Trout/Dolly Varden in Washington State June 1992. Washington Department of Wildlife. Olympia, Washington.

Point No Point Treaty Council, U.S. Fish and Wildlife Service, and Washington Department of Fisheries. 1986. Hood Canal Salmon Management Plan.

Point No Point Treaty Council, U. S. Fish and Wildlife Service, and Washington Department of Fisheries. 1989. Hood Canal Production Evaluation Program (Memorandum of Understanding).

Puget Sound Salmon Management Plan. 1985. U.S. v Washington, 384 F. supp.312; sub no. 85-2 (W.D. Wash.), Seattle, Washington.

Reisenbichler, R. R. and S.P. Rubin. 1999. Genetic changes from artificial propogation of Pacific salmon affect the productivity and viability of supplemented populations. ICES Journal of Marine Science 56:459-166.

Seidel, Paul. 1983. Spawning Guidelines for Washington Department of Fisheries Hatcheries. Washington State Department of Fisheries. Olympia, Washington.

U. S. Forest Service. 1992. Big Quilcene Stream Survey Report. Quilcene Ranger District, Quilcene, Washington.

U. S. Fish and Wildlife Service. 2000. Fish Passage Program Guidance (draft). Washington D.C.

Washington Department of Fisheries. 1975. A Catalog of Washington Streams and Salmonid Utilization. Hood Canal Region. Olympia, Washington.

Washington Department of Fish and Wildlife and Point No Point Treaty Tribes. 2000. Summer Chum Salmon Conservation Initiative (An Implementation Plan to Recover Summer Chum in the Hood Canal and Strait of Juan de Fuca Region). Olympia, Washington.

Zajac, David. 1989. Adult coho passage issue at Quilcene NFH. Memorandum dated October 11, 1989, to Project Leader, Fisheries Assistance Office, FWS, Olympia, Washington.