Biological Monitoring
Goldsborough Creek, Washington
1999 Spawning Survey
Data Report
-FINAL-

Prepared for:

U.S. Army Corps of Engineers, Seattle District
4735 E. Marginal Way
Seattle, Washington 98124-2255

Prepared by:

R2 Resource Consultants, Inc.
15250 NE 95th St.
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1. INTRODUCTION

Goldsborough Creek, located in the foothills of the southern Olympic Peninsula, Washington, is the site of a Section 206 Restoration Project conducted under the authority of the Water Resources Development Act by the U.S. Army Corps of Engineers, Seattle District (USACE). The Goldsborough Creek Project entails the removal of a dam located at RM 2.3. The stream in the vicinity of the existing dam will be stabilized to establish a gradual drop over several thousand feet of stream (Tetra Tech 1999). The objective of the project is to re-establish an upstream and downstream connection for anadromous salmon between upper Goldsborough Creek and Hood Canal (USACE 1999).

Goldsborough Creek is located near the City of Shelton, along the southwest corner of Hood Canal in Mason County, Washington. Goldsborough Creek (WRIA 14.0035) is approximately 14 mi long and has a drainage basin of approximately 55 mi^2 (Williams et al. 1975; USFWS 1999; USACE 1999). The headwaters for Goldsborough Creek originate from several small spring-fed lakes which supply water to the North and South forks (Figure 1). Mean monthly discharge ranges from a low of 20 cfs in September to 400 cfs in February (mean annual discharge = 117 cfs) (Williams et al. 1975). Most of the upper drainage basin is composed of second growth timber, while the lower basin (i.e., downstream from RM 2) flows through the City of Shelton before emptying into Oakland Bay. The two largest tributaries, Coffee and Winter creeks, are located near RM 1.7 and RM 9, respectively. Coffee Creek is approximately 2.1 mi long and enters Goldsborough Creek near Shelton; Winter Creek, 4.5 mi long, is a tributary to the North Fork of Goldsborough Creek near Wells, Washington.

The original dam on Goldsborough Creek was constructed in the late 1800s by Satsop Railroad in order to store logs before they were transported downstream to Shelton (Seavey 1999). The current dam, a 14-ft-high timber-wall dam, was built in 1932 by Rainier Pulp and Paper Company to supply water to their pulp mill, located in Oakland Bay. The original dam was constructed with a fishway, however it became inoperable over time due to erosion downstream from the dam. Additional structures (i.e., sheet pile weir and timber piles) have been added to the dam to create a "four-step" structure (USACE 1999). Today, the spillway discharges onto a shallow, concrete-lined pool/step and then drops another 15 ft into a plunge pool (Figure 2). Modifications made to the original structure in 1932 also included a new fishway located on the left side of the stream (Figure 3). Total vertical displacement through the dam from the crest to the plunge pool is approximately 35 ft. Like the old facility, the

existing fishway now appears to prevent upstream migration of chum salmon (*Oncorhynchus keta*) and restrict the upstream movement of coho (*O. kisutch*) under certain hydraulic conditions (Seavey 1999; USACE 1999).

The Goldsborough Creek Restoration Project consists of the following tasks: removal of a portion of the timber pile and concrete structure; excavation of the sediment deposited upstream of the dam; placement of fill material downstream of the dam; construction of weirs within the area currently occupied by the dam to control gradient and provide velocity refugia for upstream migrating salmonids; and bank protection/revegetation activities. The project is a collaborative effort between the USACE and Simpson Timber Company under Section 206 of Water Resources Development Act. Feasibility studies were completed in 1999 and the project received approval in September 1999 by the USACE, North Pacific Division. In September 1999, the USACE contracted with R2 Resource Consultants (R2), to conduct biological monitoring in Goldsborough Creek. The objective of this study is to obtain pre-dam removal data on the timing and distribution of salmon spawning in Goldsborough Creek. Specifically, the scope of work identified two tasks:

- Conduct spawner surveys in Goldsborough Creek during the chum, coho, and chinook (*O. tshawytscha*) salmon spawning season; and
- Prepare a spawning survey data report, describing both the number of fish observed and the number of fish days for chum, coho, and chinook salmon.

The following report describes the methods and results of the adult spawner surveys. We have included descriptions of the physical conditions (water clarity and temperature) in the survey reaches and incorporated the results of previous adult spawner surveys to facilitate comparisons over time. This report will help assess the success of the Goldsborough Creek Restoration Project relative to upstream fish passage.

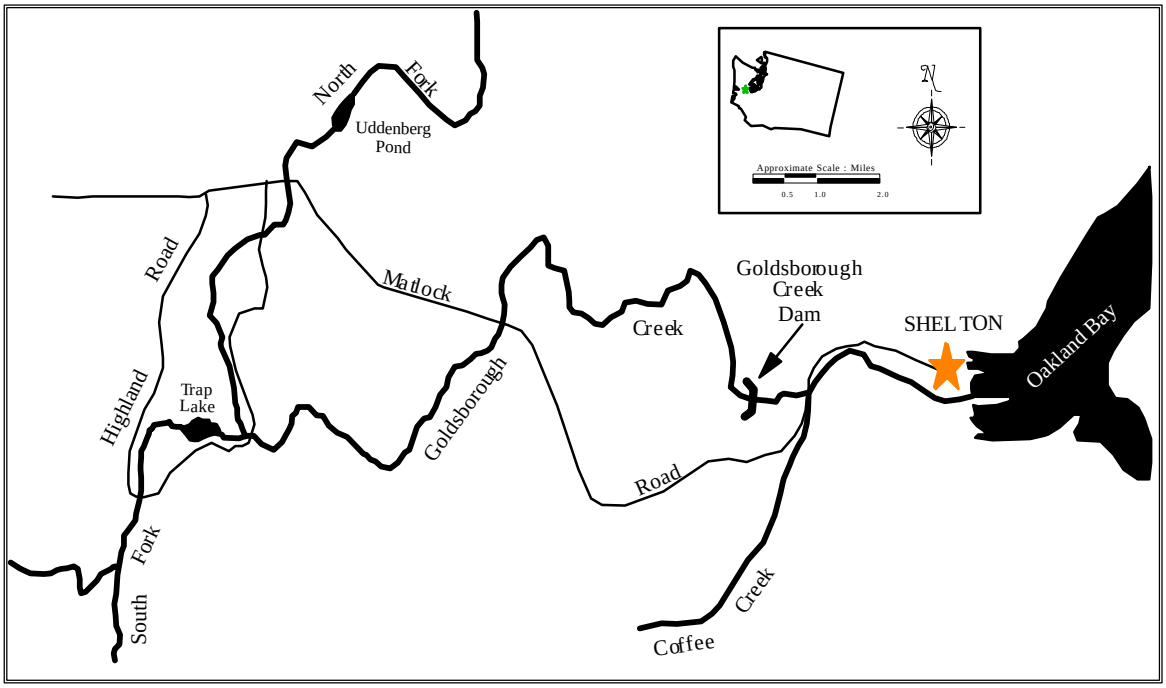

Figure 1. Goldsborough Creek drainage basin, Mason County, Washington (base map adapted from Williams et al. 1975).

Figure 2. Goldsborough Creek Dam, Mason County, Washington, 1999.

Figure 3. Goldsborough Creek Dam fishway entrance, Mason County, Washington, 1999.

2. BIOLOGICAL SETTING

Goldsborough Creek supports populations of both resident and anadromous fish species. Chum, coho, and chinook salmon, coastal cutthroat trout (*O. clarki clarki*) and steelhead (*O. mykiss*) are known to spawn in Goldsborough Creek (Williams et al. 1975; Bernard 1999), while bull trout *(Salvelinus confluentus*) are present in many drainages on the Olympic Peninsula (Spalding 1997). The following section describes key life history characteristics and residency periods for each of the aforementioned species.

2.1 CHINOOK SALMON

Chinook salmon are the largest of all Pacific salmon, and can weigh over 100 pounds, however the average weight is closer to 22 pounds. Chinook salmon, the least abundant of the five Pacific salmon species, were historically found from the Ventura River, California to Point Hope, Alaska (Meyers et al. 1998). Presently, spawning populations of chinook exist from the San Joaquin River to the Kotzebue Sound, Alaska (Healey 1991). Chinook salmon are differentiated into two primary juvenile behavioral forms, ocean-type and stream-type, based on their pattern of freshwater rearing. Juvenile ocean-type chinook salmon migrate to the marine environment during the first year of life, generally within three to four months of emergence (Lister and Genoe 1970). Juvenile stream-type chinook salmon rear in freshwater for a year or more before outmigrating to the ocean. The population of chinook salmon in a single river system may exhibit variations in these freshwater rearing strategies depending on annual variations in food supply, water temperature and other environmental factors. Differences between these life history patterns are accompanied by differences in morphological and genetic attributes (Myers et al. 1998). Chinook salmon classification is further divided by the timing of upstream migration (e.g., spring or fall/summer runs).

The principal stock of chinook salmon present in Goldsborough Creek is summer/fall ocean-type chinook. Adult summer/fall chinook migrate upstream from late June to mid-November. Spawning takes place from mid-September through mid-November. The juveniles may migrate to the ocean in the first three months of life. Ocean-type chinook depend heavily on estuaries for juvenile rearing to achieve a larger size before moving off-shore. Juvenile chinook (n = 44; mean FL = 86 mm) were captured in a screw trap operated in Goldsborough Creek near RM 0.3 in 1999 (Bernard 1999).

Goldsborough Creek summer/fall chinook are part of the Puget Sound Evolutionary Significant Unit (ESU). Overall, abundance of chinook salmon in this ESU has declined substantially, and both long- and short-term abundances are on predominantly downward trends. These factors have led to this ESU as being listed as threatened under the ESA (64 *Fed. Regist.* 11481:11520).

2.2 COHO SALMON

Coho salmon are one of the most popular and widespread sport fishes found in Pacific Northwest waters. Coho populations exist as far south as the San Lorenzo River, California and north to Norton Sound Alaska (Sandercock 1991). Goldsborough Creek coho appear to be typical of Puget Sound stocks with regard to their life histories; eighteen months in freshwater followed by eighteen months in saltwater (or up to three years) (Weitkamp et al. 1995). Juvenile coho salmon may extend their freshwater rearing period for up to two years or more (Sandercock 1991). Adult coho return and migrate upstream from early August through late January. Spawning occurs from mid-November through late January. All accessible reaches are used for spawning, with mainstem spawning typically heaviest in braided channel reaches.

There have been substantial releases of hatchery-origin coho salmon fry and use of remote site incubators upstream of the Goldsborough Creek Dam starting in 1955 (Weitkamp et al. 1995). Over the years, seven different stocks were used with the majority of the planted coho salmon originating from the George Adams (3.3 million) and Minter Creek (3.2 million) hatcheries. The total number of fish planted between 1955 and 1993 was 6.9 million fish. Between 1993 and 1998 about 100,000 coho salmon fry were stocked annually from Minter Creek and a remote site incubator with 30,000 eggs has operated annually since 1995 (Baranski 1999). However, WDFW and the Squaxin Island Tribe have agreed to stop all supplementation activities in Goldsborough Creek during the 8 to 10 year post-dam removal monitoring period. Baranski (1999) provided adult coho spawner count data from 1978 to 1999 for the index reach upstream of the dam. These data show an average of 419 fish per year (expressed as “fish-days”) with a range from 0 to 1,259 coho, averaging 115 coho for the last 10 years. Juvenile coho (n = 1,749; mean FL = 113 mm) were captured in a screw trap operated in Goldsborough Creek near RM 0.3 in 1999 (Bernard 1999).

Goldsborough Creek coho stocks are considered part of the Puget Sound/Strait of Georgia ESU. Continued loss of habitat, extremely high harvest rates, and a severe recent decline in

average spawner size are substantial threats to remaining native coho populations in this ESU. Currently, this ESU is not listed as threatened or endangered.

2.3 CHUM SALMON

Chum salmon, known for the large teeth and calico-patterned body color of spawning males, have the widest geographic distribution of any Pacific salmonid (Johnson et al. 1997). In North America, chum range from the Sacramento River in Monterey, California to Arctic coast streams (Salo 1991). Chum salmon typically spawn in the lower reaches of rivers in from early December to early February (WDFW et al. 1994). Juvenile chum salmon, like ocean-type chinook, have a short freshwater residence and an extended period of estuarine residence, which is the most critical phase of their life history and often determines the size of subsequent adult returns (Johnson et al. 1997).

Spawning surveys conducted in the mid-1970s found few fall chum salmon, however, recent returns to Goldsborough/Shelton Creek combined have totaled between 200 and 16,000 fish and appears to be stable (WDFW et al. 1994). Based on counts conducted in the index reach below the dam since 1987, the average spawner count (expressed as "fish-days") is 3,872, ranging from 405 to 14,479 fish per year. From 1995 to 1998, high flows resulted in poor estimates of chum escapement. Shelton Creek chum are independent of Goldsborough Creek chum salmon, but the two stocks were combined by WDFW based on geographic proximity. Genetic stock identification (GSI) indicates that this stock is distinct from other South Puget Sound stocks. Juvenile chum (n = 740; mean FL = 38 mm) were captured in a screw trap operated in Goldsborough Creek near RM 0.3 in 1999 (Bernard 1999).

Goldsborough Creek chum salmon are included in the Puget Sound/Strait of Georgia ESU. Commercial harvest of chum salmon has been increasing since the early 1970s throughout this ESU. This increased harvest, coupled with generally increasing trends in spawning escapement, provides compelling evidence that chum salmon are abundant and have been increasing in abundance in recent years within this ESU (Johnson et al. 1997). The National Marine Fisheries Service concluded that this ESU is not presently at risk of extinction, and is not likely to become endangered in the near future (63 *Fed. Regist.* 11778).

2.4 BULL TROUT

Bull trout are native to Pacific Northwest waters, historically occurring from the McCloud River in Northern California to the Yukon River in Northwest Territories, Canada. The bull trout is now considered to be extinct in northern California, and shrinking in distribution

throughout its former range. The taxonomic status of the bull trout has been confused with that of Dolly Varden. Bull trout were differentiated from Dolly Varden in 1978 (Cavender 1978) and recognized as a separate species by the American Fisheries Society in 1980. Both species are native salmonids and members of the Genus Salvelinus. The species are similar in coloration, morphology, and life history, making distinction between the two species difficult without the use of electrophoretic samples or measurements of morphometric characteristics (WDFW 1997). The state of Washington has established identical protective measures and management for the two species (WDFW 1997). Bull trout are distributed primarily inland as a resident species; however, several populations have been identified as anadromous. Bull trout within the Puget Sound ESU are proposed as threatened under ESA (63 *Fed. Regist*. 31693:31709) due to several detrimental factors (including disease, predation, increased stream temperatures, and loss of habitat). Spawning in most bull trout populations occurs during the fall, mainly in September and October. The eggs incubate and hatch in late winter or early spring. Juvenile bull trout may remain in freshwater for two to three years (or longer) before migrating to the ocean. Eighteen different populations of bull trout have been identified on the Olympic Peninsula, however little information exists on the presence or absence of bull trout in the Goldsborough Creek drainage (Spalding 1997).

2.5 STEELHEAD

Steelhead, displaying perhaps the most diverse life history pattern of all Pacific salmonids, reside in most Puget Sound streams. Their historic native distribution extended from northern Mexico to the Alaska Peninsula. Presently, spawning steelhead are found as far south as Malibu Creek, California (Busby et al. 1996). Two different genetic groups (coastal and inland) of steelhead are recognized in North America (Busby et al. 1996). Both coastal and inland steelhead occur in British Columbia, Washington, and Oregon; while Idaho stocks are of the inland form and California steelhead stocks are all of the coastal variety (Busby et al. 1996). Within these groups, steelhead are further divided based on the state of sexual maturity when they enter freshwater. Stream-maturing steelhead (also called summer steelhead) enter freshwater in an immature life stage, while ocean maturing (or winter steelhead) enter freshwater with well-developed sexual organs (Busby et al. 1996). Goldsborough Creek steelhead (both summer and winter stocks) have been placed into the Puget Sound ESU, along with 53 other steelhead stocks, by the National Marine Fisheries Service (Busby et al. 1996). Total run size for the major stocks of this ESU was estimated at 45,000, and natural escapement of approximately 22,000 steelhead (Busby et al. 1996).

Spring and summer steelhead runs in Washington are differentiated by the timing of adult returns to freshwater. Adult steelhead entering Goldsborough Creek from November through May are considered winter steelhead (WDFW et al. 1994). Winter steelhead are native to Hammersley Inlet tributaries and spawn from February through early April (WDFW et al. 1994). Escapement of steelhead on Goldsborough Creek is not monitored by WDFW. Historically, Goldsborough Creek has received hatchery steelhead plants, however, WDFW considers any steelhead occurring in Goldsborough Creek a native stock sustained by natural production (WDFW 1994). One juvenile rainbow trout (FL = 54) was captured in a screw trap operated in Goldsborough Creek near RM 0.3 in 1999 (Bernard 1999).

Goldsborough Creek steelhead have been classified as part of the Puget Sound ESU (1 of 15 west coast steelhead ESUs). National Marine Fisheries Service indicated that, in general, the entire Puget Sound ESU is not threatened at this time. Future population declines, however, may warrant changes in ESA status (Busby et al. 1996).

2.6 COASTAL CUTTHROAT TROUT

Coastal, or anadromous cutthroat trout, are distributed on the Pacific Coast from Prince William Sound in southern Alaska to the Eel River in northern California, rarely penetrating more than 100 miles inland (Johnston 1982; Behnke 1992). Considerable information exists for Puget Sound cutthroat trout, though little of that has been collected in a standardized manner and over a long enough time period to establish trends in populations (Leider 1997).

Coastal cutthroat trout exhibit early life history characteristics similar to coho and steelhead whereby juveniles spend time rearing in freshwater before outmigrating as smolts (Leider 1997). While little information exists on Goldsborough Creek cutthroat, Puget Sound cutthroat emigrate to estuaries at a younger age (age II) and smaller size (6 inches TL) than cutthroat that are exposed to rough coastal waters (age III to V, 8-10 inches TL) (Johnston 1982). Puget Sound cutthroat trout will feed and migrate along beaches, often in waters less than 10 feet deep (Johnston 1982). Many stocks are thought to stay within estuarine habitats for their entire marine life (Leider 1997). Most cutthroat return to freshwater the same year they migrate to sea.

Juvenile cutthroat trout (n = 87; mean FL = 164 mm) were captured in a screw trap operated in Goldsborough Creek near RM 0.3 in 1999 (Bernard 1999). Goldsborough Creek coastal cutthroat trout have been classified as part of the Puget Sound ESU by the National Marine Fisheries Service (64 *Fed. Regist.* 16397). This ESU includes populations of coastal

cutthroat trout from streams in Puget Sound and the Strait of San Juan de Fuca west to, and including, the Elwha River. The southern boundaries of the Puget Sound ESU extend to Nisqually River, while the northern boundaries include coastal cutthroat trout populations in Canada (64 *Fed. Regist.* 16397). The Puget Sound coastal cutthroat trout does not warrant listing under ESA at this time; populations have been relatively stable over the past 10-15 years (64 *Fed. Regist.* 16397).

2.7 RESIDENT FISH

Little information about resident fish is available for Goldsborough Creek. Mongillo and Hallock (1997) examined the distribution and habitat of native nongame stream fishes on the Olympic Peninsula, including the Goldsborough Creek drainage. They concluded that eight nongame fish could potentially inhabit Goldsborough Creek. These fish include the speckled dace (*Rhinichthys osculus*), coastrange sculpin (*Cottus asper*), prickly sculpin (*Cottus perplexus*), reticulate sculpin (*Cottus gulosus*), riffle sculpin (*Cottus gulosus*), Pacific lamprey (*Lampetra tridentata*), three-spine stickleback (*Gasterosteus aculeatus*), and Olympic mudminnow (*Novumbra hubbsi*). Bernard (1999) also captured eulachon (*Thaleichthys pacificus*) in the Goldsborough Creek basin.

3. METHODS

3.1 SPAWNING SURVEYS

Spawning surveys were conducted from 15 October 1999 through 4 February 2000 on Goldsborough Creek. Surveys were scheduled once every two weeks during the study period. Five study reaches were surveyed based upon Missildine et al. (1999). One index reach established in 1998 by Missildine et al. (1999) was not surveyed during our study based on recommendations from the U.S. Fish and Wildlife (USFWS) and USACE project coordinators. The following index reaches in Goldsborough Creek basin were surveyed during the 1999 spawning season:

- Goldsborough Creek Downstream of Dam (RM 0.5-2.2);
- Goldsborough Creek Upstream of Dam (RM 2.4-3.4);
- South Fork Goldsborough Creek (RM 9.9-11.0);
- Unnamed Tributary to North Fork Goldsborough Creek (RM 0.3-0.8); and
- Coffee Creek (RM 0.0-0.3).

Spawning surveys were conducted by a single observer, beginning at the lower site boundary, moving upstream to the end of the survey reach. Newly constructed redds were marked with survey flagging tied to rocks and placed adjacent to observed redds. Subsequent survey weeks utilized flagging of a different color. Total spawner counts on a survey represented all live fish observed and those dead fish not previously counted. Dead fish were marked on each survey by removing the entire caudal fin.

Spawning data were sent to WDFW to estimate the escapement for each index reach and species. The area-under-under-the-curve methodology was used to develop the estimated escapement (R. Egan, WDFW, pers. comm.). The number of fish days was calculated using a stream life of ten (10) for chum and one (1) for coho salmon. Escapement was then adjusted to account for the estimated percentage of the fish observed on a given survey date. Finally, chum salmon were separated into summer and fall races, depending on their entrance into freshwater. Summer and fall chum runs are differentiated in Washington by the timing of adult returns to freshwater based on an arbitrary date of 1 November (WDFW et al. 1994).

3.2 PHYSICAL HABITAT PARAMETERS

Habitat utilization data were collected on chum and chinook redds located in Goldsborough Creek, downstream from the dam. Redds were located by a team of two observers during spawning surveys. Depth and velocity data were collected from each redd immediately upstream of the pit using a Swoffer Model 2100 current meter and wading rod. Substrate data were collected using WDFW and Washington Department of Ecology (1996) codes (Table 1). Data were limited to active (i.e., occupied) redds. Water temperature (to the nearest 0.5°C) was recorded in each survey reach on each survey date using a handheld thermometer. Representative photographs were taken of individual redds and index reaches. All data were transcribed onto field data sheets, entered electronically using MS Excel, and cross-referenced with original field data forms for QA/QC purposes.

Table 1. Code, description, and minimum and maximum size (inches) of substrate parameters used during Goldsborough Creek spawning surveys, 1999 (adapted from WDFW et al. 1996).

Code	Description	Minimum Size (inches)	Maximum Size (inches)
1	Silt/clay	-	-
2	Sand	-	-
3	Small gravel	0.1	0.5
4	Medium gravel	0.5	1.5
5	Large gravel	1.5	3.0
6	Small cobble	3.0	6.0
7	Large cobble	6.0	12.0
8	Boulder	>12.0	-
9	Bedrock	-	-

4. RESULTS AND DISCUSSION

4.1 SALMONID SPAWNING

A total of nine spawning surveys were conducted from 15 October 1999 through 4 February 2000. Originally, surveys were to begin on the first week of October; however, the WDFW staff conducted a spawning survey during the first week of October (R. Egan; WDFW; *pers. comm*.). To avoid duplication, our survey began one week later and continued for one additional week than originally scheduled. Chinook and chum salmon were the only species encountered during the surveys. No adult fish were observed upstream of the Goldsborough Creek Dam. The results of individual index reaches and discussion are presented in their respective sections below.

4.1.1 Goldsborough Creek RM 0.5-2.2

The 1999 survey effort covered approximately 8,900 ft of stream in Goldsborough Creek downstream of the dam (Figures 4 and 5). An estimated 57 summer chum (25 October through 1 November) and 182 fall chum salmon spawned in Goldsborough Creek downstream of the dam in 1999. Utilizing the area-under-the-curve methodology and a stream life of ten (10) days for chum salmon, 570 summer chum fish days and 1,820 fall chum fish days (2,390 fish days total) occurred in Goldsborough Creek downstream of the dam. The number of spawning chum salmon occurring during 1999 was approximately 14 percent of the total number of chum fish days estimated in 1998 (16,975), when approximately 1,697 chum spawned in Goldsborough Creek downstream of the dam (Missildine et al. 1999). The number of live chum salmon observed in Goldsborough Creek peaked twice during the study period; 15 October (40 chum observed) and 7 January (27 chum observed) (Figure 6; Table A-1). As in 1998, stream conditions (i.e., high turbidity and flow) hampered survey efforts. Our estimate of 2,390 total chum days is probably low taking into account the physical conditions in the stream during the survey period. Physical stream conditions were very similar in 1998 and 1999, and we believe the decrease in the number of chum salmon observed spawning in Goldsborough Creek in 1999 is an accurate observation. The number of summer chum estimated from WDFW surveys in 1999 was more than twice as high as our estimate (128 to 57); however, WDFW staff were not able to estimate the number of fall chum salmon in Goldsborough Creek due to poor physical conditions present during their surveys (R. Egan, WDFW, *pers. comm*.). No coho were observed downstream of the dam in Goldsborough Creek during 1999 (R. Egan, WDFW, *pers. comm*.). Several

adult chinook were observed spawning in Goldsborough Creek during 1999, but chinook escapement could not be calculated due to their low numbers (Table A-1).

4.1.2 Goldsborough Creek RM 2.4-3.4

The 1999 survey effort covered approximately 5,280 ft of stream in Goldsborough Creek upstream of the dam during nine surveys (Figures 7 and 8). No adult salmonids were observed upstream of the dam during the 1999 study period (Table A-2). One dead overyearling coho was found approximately 3,500 ft upstream of the dam on 10 November.

4.1.3 South Fork Goldsborough Creek RM 9.9-11.0

The 1999 survey effort covered approximately 5,800 ft of stream in the South Fork Goldsborough Creek (Figures 9 and 10). No adult salmonids were observed in the South Fork Goldsborough Creek during the 1999 study period (Table A-3). Likewise, WDFW survey personnel did not observe coho salmon spawning in the South Fork Goldsborough Creek index reach during 1999 (R. Egan, WDFW, *pers. comm*.).

4.1.4 Unnamed Tributary to North Fork Goldsborough Creek RM 0.3-0.8

The 1999 survey effort covered approximately 2,640 ft of stream in an unnamed tributary to North Fork Goldsborough Creek (Figures 11 and 12). No adult salmonids were observed during the 1999 study period (Table A-4).

4.1.5 Coffee Creek RM 0.0-0.3

The 1999 survey effort covered approximately 1,580 ft of stream in Coffee Creek (Figures 13 and 14). An estimated 65 chum salmon spawned in Coffee Creek during 1999. There was not enough adult summer chum observed to compute total summer chum escapement, hence all chum were combined to derive an estimate for total number of chum salmon escaping to Coffee Creek. Utilizing the area-under-the-curve methodology and a stream life of ten (10) days for chum salmon, 650 chum fish days occurred in Coffee Creek. Our estimate of chum salmon fish days in 1999 was approximately 11 percent of the total number of chum fish days estimated in 1998 (5,830), when approximately 583 chum spawned in Coffee Creek (Missildine et al. 1999). The number of live chum salmon observed in Coffee Creek peaked twice during the study period; 10 November (9 chum observed) and 4 December (12 chum observed) (Figure 15; Table A-5). The number of summer chum estimated from WDFW

surveys in 1999 was more than three times higher than our estimate (208 to 65) (R. Egan, WDFW, *pers. comm.*). No coho salmon were observed in Coffee Creek during the 1999 study period by either R2 or WDFW staff.

4.1.6 Summary

Total escapement to the Goldsborough Creek basin appeared to decrease in 1999 when compared to previous survey years. The estimated 1999 chum salmon escapement of 239 was the lowest on record, only the 1997 spawning season when an estimated 405 chum salmon spawned downstream of the dam was near to the 1999 spawning year (Figure 16; Table A-6). Likewise, coho escapement estimated during 1999 in the South Fork Goldsborough Creek matched all-time lows (0) recorded during the 1992, 1993, and 1996 spawning seasons (Figure 17; Table A-6). No adult anadromous salmonids were observed upstream of the dam during 1999. Adult chum were observed in the lower plunge pool below the dam periodically, however they were not observed at any time in the fish ladder (J. Ficklin, Simpson Timber, *pers. comm.*).

4.2 PHYSICAL HABITAT PARAMETERS

Spawning habitat utilization data were collected on fourteen (14) chum salmon redds located downstream of the dam in Goldsborough Creek (Table A-7). The average depth (0.8 ft), velocity (1.87 fps), and substrate of redds measured in Goldsborough Creek correspond to spawning preference values collected from summer and fall chum salmon spawning in Kennedy Creek, Duckabush River, and Dosewallips River by the WDFW and WDOE (WDFW et al. 1996).

Figure 4. Upstream end of Goldsborough Creek index reach located downstream of dam (RM 0.5-2.2), 1999.

Figure 5. Downstream end of Goldsborough Creek index reach located downstream of dam (RM 0.5-2.2), 1999.

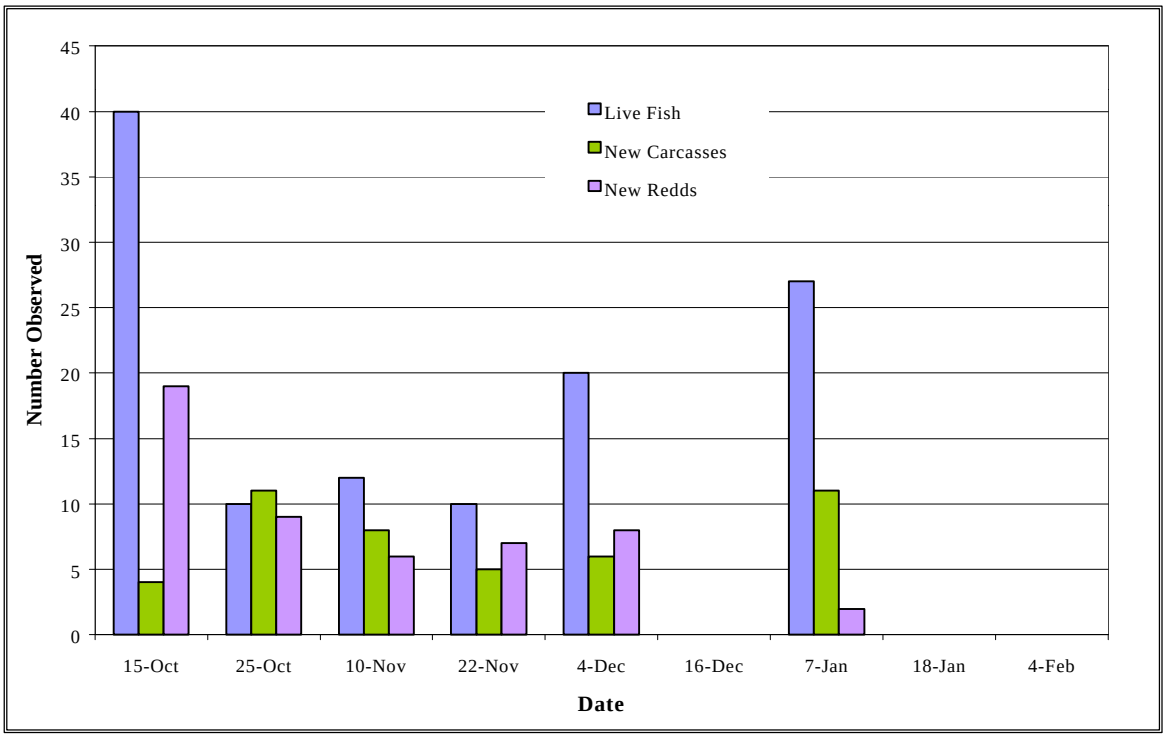

Figure 6. Number of live chum, new carcasses, and dead chum salmon observed during spawning surveys conducted in Goldsborough Creek downstream of dam (RM 0.5-2.2), 1999.

Figure 7. Upstream end of Goldsborough Creek index reach located upstream of dam (RM 2.4-3.4), 1999.

Figure 8. Downstream end of Goldsborough Creek index reach located upstream of dam (RM 2.4-3.4), 1999.

Figure 9. Upstream end of South Fork Goldsborough Creek index reach (RM 9.9-11.0), 1999.

Figure 10. Downstream end of South Fork Goldsborough Creek index reach (RM 9.9-11.0), 1999.

Figure 11. Upstream end of unnamed tributary to North Fork Goldsborough Creek index reach (RM 0.0-0.8), 1999.

Figure 12. Downstream end of unnamed tributary to North Fork Goldsborough Creek index reach (RM 0.0-0.8), 1999.

Figure 13. Upstream end of Coffee Creek index reach (RM 0.0-0.3), 1999.

Figure 14. Downstream end of Coffee Creek index reach (RM 0.0-0.3), 1999.

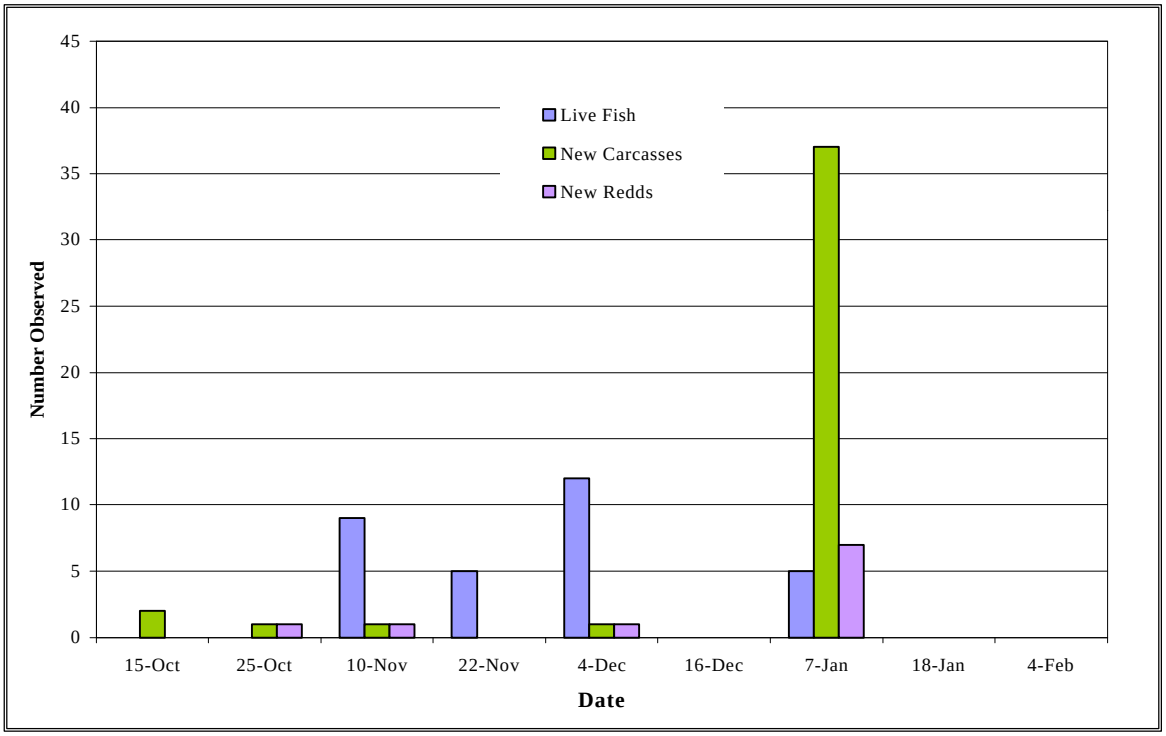

Figure 15. Number of live chum, new carcasses, and dead chum salmon observed during spawning surveys conducted in Coffee Creek (RM 0.0-0.3), 1999.

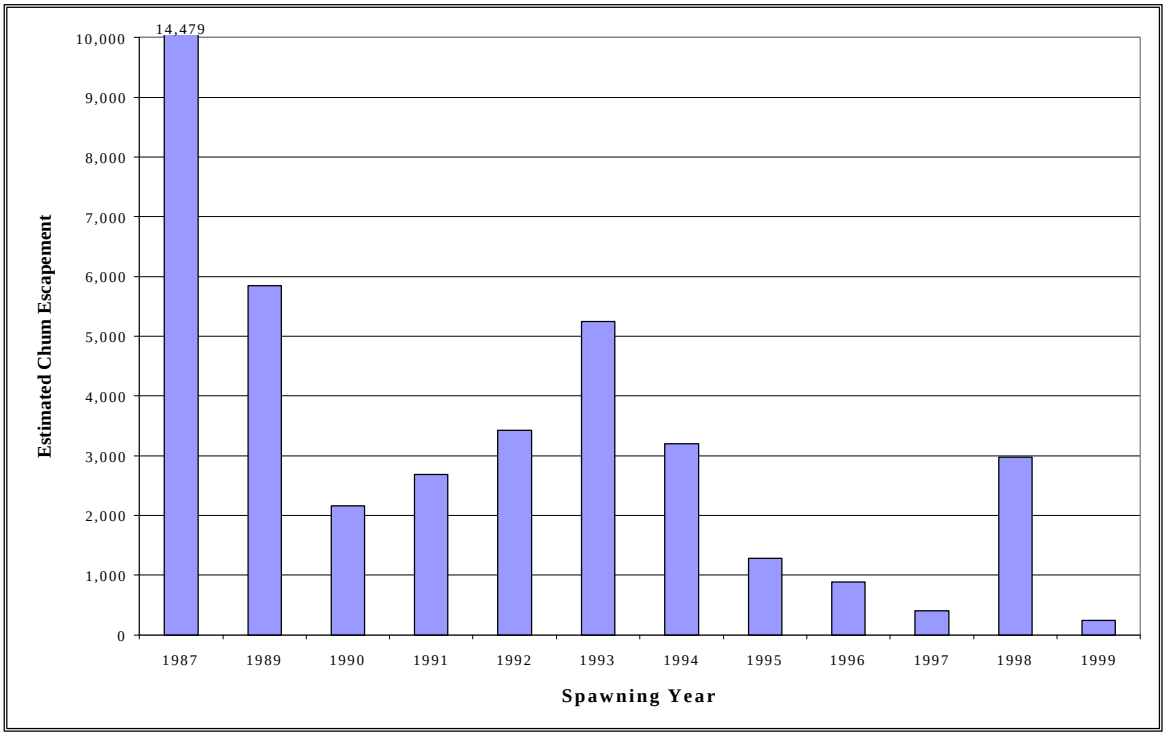

Figure 16. Estimated chum salmon escapement to Goldsborough Creek, Washington (RM 0.5-2.2), 1987-1999 (adapted from Seavey 1999).

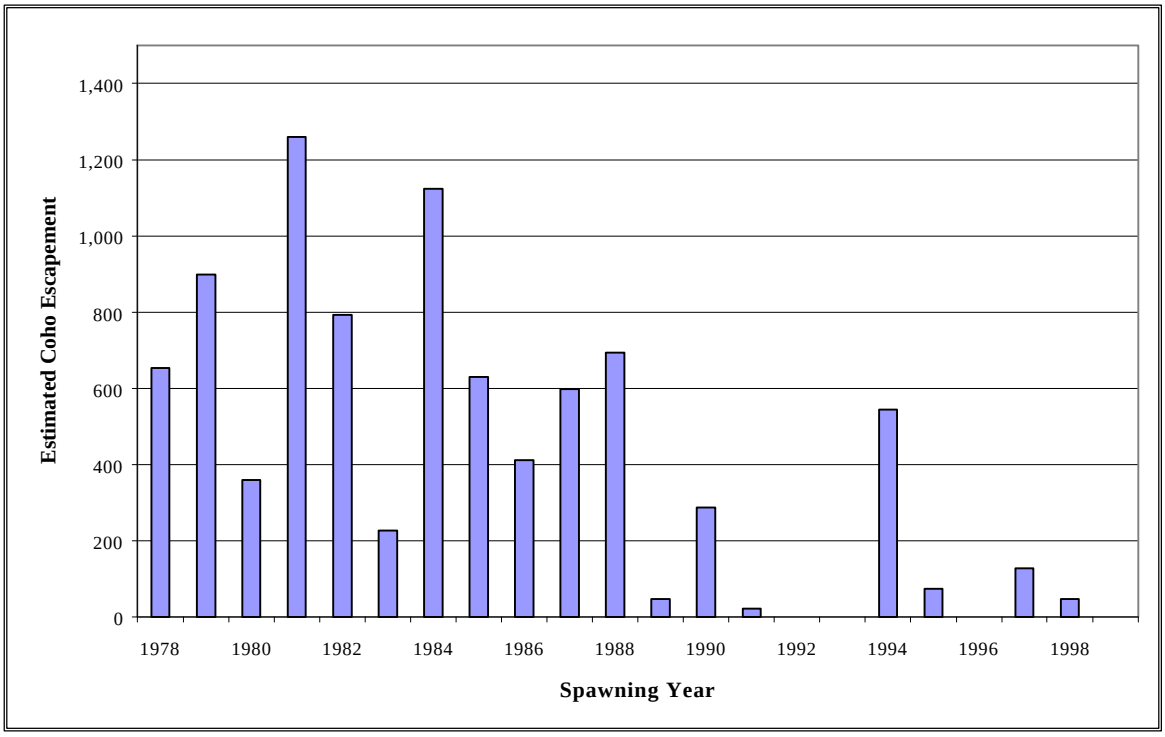

Figure 17. Estimated coho salmon escapement to the South Fork Goldsborough Creek, Washington (RM 9.9-11.0), 1978-1999 (adapted from Seavey 1999).

5. REFERENCES

Anchor Environmental, L.L.C., Parametrix, Inc., and Associated Firms. 1998. Goldsborough Creek Restoration Project: technical analysis. Prepared for Simpson Timber Company. August 1998. Shelton, Washington. ~225 p.

Behnke, R.J. 1992. Native trout of western North America. American Fisheries Society Monograph 6. Bethesda, Maryland.

Bernard, R. 1999. Pacific salmon treaty implementation funding progress report, FY-99: Squaxin Island Tribe south Puget Sound smolt trapping, 1999. Prepared for the Pacific Salmon Treaty Implementation Funding and the Squaxin Island Tribe. December 1999. 35 p.

Busby, P.J., T.C. Wainwright, G.J. Bryant, L.J. Lierheimer, R.S. Waples, F.W. Waknitz, and I.V. Lagomarsino. 1996. Status review of west coast steelhead from Washington, Oregon, and California. National Oceanic and Atmospheric Administration (NOAA) Technical Memorandum NMFS-NWFSC-27, Seattle, Washington.

Cavender, T.M. 1978. Taxonomy and distribution of the bull trout, *Salvelinus confluentus*, (Suckley), from the American Northwest. California Fish and Game 64:139-174.

Cook-Tabor, C., and L. Moore. 1999. Ambient habitat monitoring of Lower Goldsborough Creek - 1998. U.S. Fish and Wildlife Service. Draft. Lacey, Washington. 32 pp.

Healey, M.C. 1991. Life history of chinook salmon (*Oncorhynchus tshawytscha*). Pages 311-393 *in* C. Groot and L. Margolis, editors. Life history of Pacific Salmon. University of British Columbia Press. Vancouver, British Columbia.

Johnson, O.W., W.S. Grant, R.G. Cope, K. Neely, R.W. Waknitz, and R.S. Waples. 1997. Status review of chum salmon from Washington, Oregon, and California. U.S. Department of Commerce, NOAA Technical Memorandum NMFS-NWFSC-32.

Johnson, O.W., M.H. Ruckelshaus, W.S. Grant, F.W. Waknitz, A.M. Garrett, G.J. Bryant, K. Neely, and J.J. Hard. 1999. Status review of coastal cutthroat trout from Washington, Oregon, and California. U.S. Department of Commerce, NOAA Technical Memorandum. NMFS-NWFSC-37. 292 p.

Johnston, J.M. 1982. Life histories of anadromous cutthroat trout with emphasis on migratory behavior. Pages 123-127 *in* E.L. Brannon and E.O. Salo, editors. Salmon and trout migratory behavior symposium. School of Fisheries, University of Washington, Seattle, Washington.

Laufle, J.C., G.B. Pauley, and M.F. Shepard. 1986. Species profiles: life histories and environmental requirements of coastal fishes and invertebrates (Pacific Northwest) - coho salmon. U.S. Fish Wildlife Service Biological Report 82(11.48). U.S. Army Corps of Engineers, TR EL-82-4.

Leider, S.A. 1997. Status of sea-run cutthroat trout in Washington. Pages 68-76 *in* J.D. Hall, P.A. Bisson, and R.E. Gresswell, editors. Sea-run cutthroat trout biology, management, and future conservation. Oregon Chapter American Fisheries Society, Corvallis, Oregon.

Lister, D.B., and H.S. Genoe. 1970. Stream habitat utilization by cohabiting underyearlings of chinook (*Oncorhynchus tshawytscha*) and coho (*O. kisutch*) salmonids. Journal of Fisheries Research Board of Canada 27:1215-1224.

Missildine, B.R., R.J. Peters, and D.L. Low. 1999. Chinook, coho, and chum salmon spawner escapement estimates - 1998. Prepared by the U.S. Fish and Wildlife Service. July 1999. Lacey, Washington. 8 p.

Mongillo, P.E. and M. Hallock. 1997. Distribution and habitat of native nongame stream fishes of the Olympic Peninsula. Washington Department of Fish and Wildlife. Technical Report No. FRD 97-05. Olympia, Washington. 44 p.

Myers, J.M., R.G. Kope, G.J. Bryant, D. Teel, L.J. Lierheimer, T.C. Wainwright, W.S. Grant, F.W. Waknitz, K. Neely, S.T. Lindley, and R.S. Waples. 1998. Status review of chinook salmon from Washington, Idaho, Oregon, and California. U.S. Department of Commerce, NOAA Technical Memorandum. NMFS-NWFSC-35. 443 p.

Orsborn, J.F. and P.D. Powers. 1985. Fishways - An assessment of their development and design. Department of Civil and Environmental Engineering, Washington State University, Pullman, Washington. Prepared for Bonneville Power Administration, Portland, Oregon, Contract DE-A179-82BP36523. 159 p.

Powers, P.D. and J.F. Orsborn. 1985. An analysis of barriers to upstream fish migration – An investigation of the physical and biological conditions affecting fish passage success at culverts and waterfalls. Department of Civil and Environmental Engineering, Washington State University, Pullman, Washington. Prepared for Bonneville Power Administration, Portland, Oregon, Contract DE-A179-82BP36523. 120 p.

Sabo, J.L., and G.B. Pauley. 1997. Competition between stream-dwelling cutthroat trout (*Oncorhynchus clarki*) and coho salmon (*Oncorhynchus kisutch*): effects of relative size and population origin. Canadian Journal of Fisheries and Aquatic Sciences 54:2609-2617.

Salo, E.O. 1991. Life history of chum salmon (*Oncorhynchus keta*). Pages 233-309 *in* C. Groot and L. Margolis, editors. Life history of Pacific salmon, University of British Columbia Press, Vancouver, British Columbia.

Sandercock, F.K. 1991. Life history of coho salmon (*Oncorhynchus kisutch*) Pages 397-445 *in* C. Groot and L. Margolis, editors. Pacific salmon life histories. University of British Columbia Press, Vancouver, Canada.

Schuett-Hames, D., H. Flores, and I. Child. 1996. An assessment of salmonid habitat and water quality for streams in the Eld, Totten-Little Skookum and Hammersley Inlet-Oakland Bay Watersheds in Southern Puget Sound, Washington 1993-1994. Squaxin Island Tribe.

Schuett-Hames, D., A. Pleus, L. Bullchild, and S. Hall. 1994. Ambient monitoring program. Prepared for Timber-Fish-Wildlife Program and Northwest Indian Fisheries Commission. TFW-AM9-94-001. August 1994.

Seavey, F. 1999. Fish and Wildlife Coordination Act report: Goldsborough Creek Project, Mason County, Washington. Prepared for the U.S. Army Corps of Engineers, Seattle District. Seattle, Washington. 42 p.

Spalding, S. 1997. The status and distribution of bull trout in the Olympic Peninsula. Pages 255-259 *in* W.C. Mackay, M.K. Brewin, and M. Monita, editors. Friends of the bull trout conference proceedings. Trout Unlimited Canada. Calgary, Alberta, Canada.

Tetra Tech, Inc. 1999. Goldsborough Creek Section 206 Restoration Project, Mason County, Washington: final advanced planning report. Prepared for the U.S. Army Corps of Engineers, Seattle District. 25 October 1999. Seattle, Washington. 59 p.

U.S. Army Corps of Engineers, Seattle District (USACE). 1999. Biological assessment: Goldsborough Creek Section 206 Restoration Project, Mason County, Washington. 21 September 1999. Seattle, Washington. 27 p.

U.S. Fish and Wildlife Service (USFWS). 1999. Pre-dam removal studies of Goldsborough Creek, Shelton, Washington. Prepared for the U.S. Army Corps of Engineers, Seattle District. July 1999. Seattle, Washington. 47 p.

Washington Department of Fish and Wildlife (WDFW) and Western Washington Treaty Indian Tribes. 1994. 1992 Washington State salmon and steelhead stock inventory, Appendix 1: Puget Sound stocks, Hood Canal & Straight of Juan De Fuca volume. December 1994. Olympia, Washington. 424 p.

Washington Department of Fish and Wildlife (WDFW). 1997. Washington State salmonid stock inventory: bull trout/Dolly Varden. September 1997. Olympia, Washington. 437 p.

Washington Department of Fish and Wildlife (WDFW) and Washington Department of Ecology (WDOE). 1996. State of Washington resource agencies instream flow guidelines. Olympia, Washington. 11 December 1996. ~125 p.

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

Williams, R.W., R.M. Laramie, and J.J. Ames. 1975. A catalog of Washington streams and salmon utilization: volume 2 coastal region. Prepared for Washington Department of Fisheries. November 1975. Olympia, Washington. ~300 p.

APPENDIX A
Raw Data

Biological Monitoring
Goldsborough Creek, Washington
1999 Spawning Survey
Data Report

Table A-1. Date, species, water temperature (°C), number of live and dead salmon, and number of new redds observed in Goldsborough Creek, Washington, downstream of the dam (RM 0.5-2.2), 1999.

Date	Species	Live	Dead	Redds	Water Temp.(°C)
15-Oct-99	Chinook	2	0	1	10
15-Oct-99	Chum	40	4	19	10
25-Oct-99	Chinook	0	1	0	9
25-Oct-99	Chum	10	11	9	9
10-Nov-99	Chum	12	8	6	10
22-Nov-99	Chum	10	5	7	9
4-Dec-99	Chum	20	6	8	7.5
16-Dec-99	Chum	0	0	0	9
7-Jan-00	Chum	27	11	2	9
18-Jan-00	Chum	0	0	0	6
4-Feb-00	Chum	0	0	0	8
Totals		***121***	***46***	***52***	

Table A-2. Date, species, water temperature (°C), number of live and dead salmon, and number of new redds observed in Goldsborough Creek, Washington, upstream of the dam (RM 2.4-3.4), 1999.

Date	Species	Live	Dead	Redds	Water Temp.(°C)
15-Oct-99	All	0	0	0	9
25-Oct-99	All	0	0	0	9
10-Nov-99	All	0	0	0	10
22-Nov-99	All	0	0	0	9
4-Dec-99	All	0	0	0	7.5
16-Dec-99	All	0	0	0	9
7-Jan-00	All	0	0	0	9
18-Jan-00	All	0	0	0	5
4-Feb-00	All	0	0	0	8
Totals		***0***	***0***	***0***	

Table A-3. Date, species, water temperature (°C), number of live and dead salmon, and number of new redds observed in the South Fork Goldsborough Creek, Washington (RM 9.9-11.0), 1999.

Date	Species	Live	Dead	Redds	Water Temp.(°C)
15-Oct-99	All	0	0	0	8
25-Oct-99	All	0	0	0	8.5
10-Nov-99	All	0	0	0	9
22-Nov-99	All	0	0	0	8.5
4-Dec-99	All	0	0	0	7.5
16-Dec-99	All	0	0	0	10
7-Jan-00	All	0	0	0	9
18-Jan-00	All	0	0	0	5
4-Feb-00	All	0	0	0	8
Totals		***0***	***0***	***0***	

Table A-4. Date, species, water temperature (°C), number of live and dead salmon, and number of new redds observed in unnamed tributary to the North Fork Goldsborough Creek, Washington, (RM 0.3-0.8), 1999.

Date	Species	Live	Dead	Redds	Water Temp.(°C)
15-Oct-99	All	0	0	0	9
25-Oct-99	All	0	0	0	9
10-Nov-99	All	0	0	0	9
22-Nov-99	All	0	0	0	8.5
4-Dec-99	All	0	0	0	7.5
16-Dec-99	All	0	0	0	10
7-Jan-00	All	0	0	0	9
18-Jan-00	All	0	0	0	9
4-Feb-00	All	0	0	0	8
Totals		***0***	***0***	***0***	

Table A-5. Date, species, water temperature (°C), number of live and dead salmon, and number of new redds observed in Coffee Creek, Washington (RM 0.0-0.3), 1999.

Date	Species	Live	Dead	Redds	Water Temp.(°C)
15-Oct-99	Chum	0	2	0	9
25-Oct-99	Chum	0	1	1	9
10-Nov-99	Chum	9	1	1	10
22-Nov-99	Chum	5	0	0	9
4-Dec-99	Chum	12	1	1	6
16-Dec-99	Chum	0	0	0	0
7-Jan-00	Chum	5	37	7	6
18-Jan-00	Chum	0	0	0	3
4-Feb-00	Chum	0	0	0	8
Totals		***31***	***42***	***10***	

Table A-6. Estimated coho and chum salmon escapement in two reaches of Goldsborough Creek, Washington, 1978-1999.

Year	Estimated Escapement	
	Coho RM 9.9-11.0[1]	Chum RM 0.5-2.2[2]
1978	653	-
1979	898	-
1980	360	-
1981	1,259	-
1982	792	-
1983	228	-
1984	1,123	-
1985	630	-
1986	411	-
1987	598	14,479
1988	694	-
1989	48	5,843
1990	287	2,166
1991	22	2,687
1992	0	3,428
1993	0	5,250
1994	544	3,199
1995	74	1,283
1996	0	888
1997	128	405
1998	47	2,969
1999	0	239

[1] Zero indicates that no coho were observed in study section during that spawning year.

[2] Dash lines indicate that the study section was not surveyed during that spawning year.

Table A-7. Length (ft), width (ft), depth (ft), velocity (fps), and dominant and subdominant substrate of chum salmon redds observed in Goldsborough Creek, Washington (RM 0.5-2.2), 1999.

Redd Number	Length (ft)	Width (ft)	Depth (ft)	Velocity (fps)	Dominant Sub	Sub-dominant Sub
1	10	3	1	1.4	3	5
2	8	4	1	1.55	3	5
3	10	5	1	1.62	6	5
4	12	4	0.75	1.58	6	5
5	8	3	0.5	1.75	3	5
6	12	5	0.5	1.8	3	5
7	14	6	0.75	2.3	3	5
8	12	7	0.5	2.25	3	5
9	12	4	0.5	2.1	3	5
10	15	20	1	1.78	3	5
11	15	10	1.5	1.92	3	5
12	20	15	1	1.95	5	3
13	10	5	1	1.99	3	2
14	25	20	0.75	2.23	3	2
Mean	***13.1***	***7.9***	***0.8***	***1.87***		