Biological Monitoring
Goldsborough Creek, Washington
2001 Spawning Survey

Data Report

-FINAL-

Prepared for:

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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 Restoration Project entailed the removal of a dam located at River Mile (RM) 2.3. The stream in the vicinity of the dam was 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 South Puget Sound (USACE 1999a). The Goldsborough Creek Project was completed in late summer of 2001.

Goldsborough Creek is located near the City of Shelton, south 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 1999a). 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 9.0, 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 to store logs before they were transported downstream to Shelton (Seavey 1999). The updated 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 that was located in Oakland Bay (Figure 2). 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) were added to the dam to create a "four-step" structure (USACE 1999a). The spillway discharged onto a shallow, concrete-lined pool/step and then dropped another 15 ft into a plunge pool (Figure 2). Modifications to the original structure in 1932 also included a new fishway located on the left side of the stream. Total vertical displacement through the dam from the crest to the plunge pool was approximately 35 ft. Like the old facility, the updated

fishway appeared 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 1999a).

The Goldsborough Creek Restoration Project consisted of the following tasks: removal of the timber pile and concrete structure; excavation of approximately 25,000 yd^3 of sediment deposited upstream of the dam; placement of fill material downstream of the dam to re-establish channel gradient; 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 was 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. The project construction was completed in the fall of 2001 (Figure 3). Bank protection and revegetation activities are still ongoing.

There are 36 weirs in the Project Area (i.e., downstream-most weir to upstream-most weir) arranged in six groups of five and one group of six (the downstream-most weir group). There is approximately 35 ft between individual weirs, and each weir group is separated by 100 to 275 linear ft of stream channel. The overall slope of the Project Area is designed to be 2.3%, with approximately 3.6% slope within each weir (USACE 1999b). Each weir is designed to provide unhindered upstream and downstream fish passage at varying flow levels (Figures 4 and 5). Each weir is designed to have a maximum 12 inch elevation drop to ensure fish passage. During project construction Goldsborough Creek was routed around the Project Area through a temporary bypass pipe. A stilling basin was placed at the bypass pipe outlet to serve as a sediment trap. After the bypass pipe was in place, a concerted effort was made to collect and transport as many fish as possible out of the dewatered Project Area. When the pipe was removed, the stilling basin was left to continue to filter sediments being flushed downstream by the return of the creek to its channel.

The USACE contracted with R2 Resource Consultants (R2), to conduct biological monitoring in Goldsborough Creek. The objective of this study is to obtain pre- and post-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 (*Oncorhynchus keta*), coho (*O. kisutch*), 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.

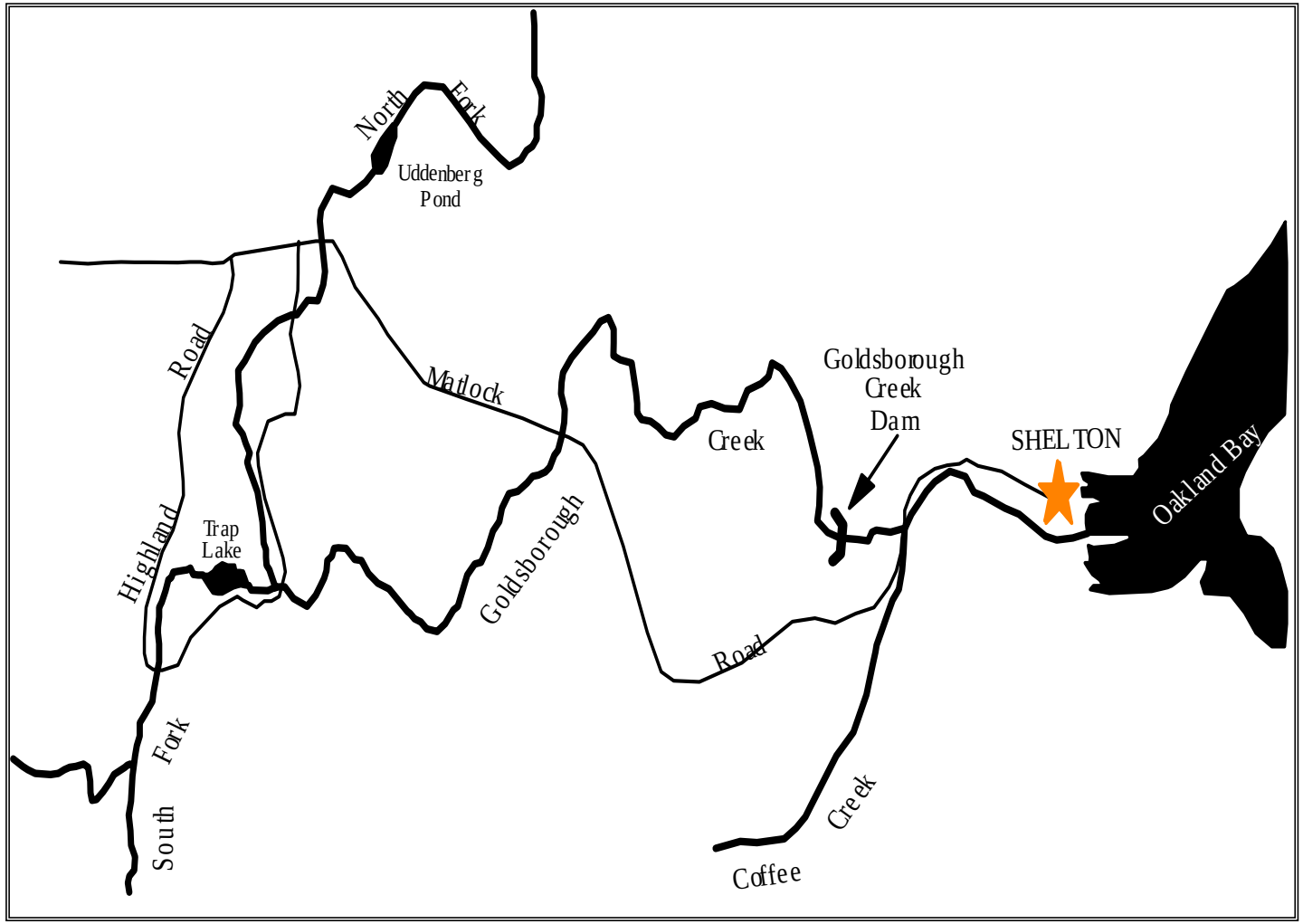

Figure 1. Goldsborough Creek drainage basin, Mason County, Washington (base map adapted from Williams et al. 1975).

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

Figure 3. Goldsborough Creek Restoration Project Area during construction, August 2001, Mason County, Washington.

Figure 4. Goldsborough Creek Restoration Project Area, low flow conditions 2001, Mason County, Washington.

Figure 5. Goldsborough Creek Restoration Project Area, high flow conditions 2001, Mason County, Washington.

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, California 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 early August 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 = 105; mean FL = 79 mm) were captured in a screw trap operated in Goldsborough Creek near RM 0.3 in 2000 (Celedonia et al. 2000).

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 September 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, Washington Department of Fish and Wildlife (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 = 4,963; mean FL = 113 mm) were captured in a screw trap operated in Goldsborough Creek near RM 0.3 in 2000 (Celedonia et al. 2000).

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 return to tributaries in October and November and 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 fall 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 combined stock is distinct from other South Puget Sound stocks. Juvenile chum (n = 692) were captured in a screw trap operated in Goldsborough Creek near RM 0.3 in 2000 (Celedonia et al. 2000).

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. 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). No bull trout were captured in a screw trap operated in Goldsborough Creek near RM 0.3 in 2000 (Celedonia et al. 2000).

Bull trout within the Puget Sound ESU were listed as threatened under ESA (64 *Fed. Regist*. 58911:58932) due to several detrimental factors (including disease, predation, increased stream temperatures, and loss of habitat). Likewise, Dolly Varden were proposed as threatened under ESA due to their similarity of appearance to bull trout (66 *Fed. Regist*. 1628:1632).

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 along the Pacific Coast from 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; natural escapement was estimated at 22,000 steelhead (Busby et al. 1996).

Winter 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). Juvenile steelhead (n = 53; mean FL = 162) were captured in a screw trap operated in Goldsborough Creek near RM 0.3 in 2000 (Celedonia et al. 2000).

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 = 222; mean FL = 155 mm) were captured in a screw trap operated in Goldsborough Creek near RM 0.3 in 2000 (Celedonia et al. 2000).

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 27 August 2001 through 15 February 2002 on Goldsborough Creek. Surveys were scheduled once every two weeks during the study period. However, high streamflows and project construction made adaptations to this schedule necessary. No surveys were completed through or above the project construction area (i.e., the bypass pipe upstream to the upstream-most weir) until 11 October 2002 at which time the stream had been returned to the main channel. Five study reaches were surveyed based upon Missildine et al. (1999) and Jeanes and Hilgert (2000). The following index reaches in Goldsborough Creek basin were surveyed during the 2001 spawning season:

- Lower Goldsborough Creek - through and downstream of the Project Area (RM 0.5-2.2);
- Middle Goldsborough Creek – immediately upstream of the Project Area (RM 2.3-3.4);
- Upper Goldsborough Creek - upstream of the Project Area, near Carmen Rd. (RM 5.8-6.7);
- South Fork Goldsborough Creek (RM 9.9-11.0); and
- Coffee Creek (RM 0.0-0.3).

Spawning surveys were conducted by a single observer walking upstream, beginning at the lower site boundary, and proceeding 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.

Water temperature (to the nearest 0.5°C) and stage (to the nearest (0.01 ft) were recorded on each survey date using a handheld thermometer and staff gage measurements, respectively. 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.

4. RESULTS AND DISCUSSION

4.1 SALMONID SPAWNING

A total of thirteen spawning surveys were conducted from 27 August 2001 through 15 February 2002. Chinook, chum, coho salmon and cutthroat trout were the only species encountered during the surveys. Cutthroat trout observations were incidental and were not enumerated. High streamflow conditions occurred during November and early December 2001 and prevented reliable survey information from being attained during this period. The results of individual index reaches and discussion are presented in their respective sections below.

4.1.1 Lower Goldsborough Creek RM 0.5-2.2

The 2001 survey effort covered approximately 8,900 ft of stream in Goldsborough Creek beginning at the 7th street bridge in Shelton, proceeding upstream through the Project Area and ending at the upstream-most weir just above the railroad bridge (Figures 6 and 7). Surveys of this reach were limited by project construction. Surveys on 27 August, 10 September and 25 September were conducted upstream to outfall of the bypass pipe. An estimated 248 chum salmon spawned in Goldsborough Creek downstream of the Project Area in 2001. While live fish were observed in the Project Area after construction was completed, no spawning activity was recorded within the weirs.

Utilizing the area-under-the-curve methodology and a stream life of ten (10) days for chum salmon, 2,480 total fish days occurred in Goldsborough Creek through and downstream of the Project Area. The number of chum fish days occurring during 2001 was nearly identical to the total number of chum fish days estimated in 1999 (2,390) and 2000 (2,360) (Missildine et al. 1999 and R2 2000) (Table 1). The number of live chum salmon observed in Lower Goldsborough Creek peaked on 25 November (26 chum) (Figure 8; Table A-1). Low numbers of chinook (N=7) were observed during September and the first survey conducted in October. Unlike year 2000 survey efforts, high streamflows impaired survey conditions (i.e., water clarity) throughout the 2001 field effort. Specifically, streamflows were too high record reliable survey estimates in this index section on 10 November, 24 November and 6 December 2001. In addition, turbulence caused by the weirs, and depth of weir pools impaired survey visibility within Project Area.

Table 1. Summary of live salmon counts for five index reaches established in the Goldsborough Creek basin, 1999-2001. Data from R2 Resource Consultants and WDFW (escapement estimates in parentheses when available).

	1999	2000	2001
Coffee Creek			
Chinook	0	0	0
Chum	31	20	291 (814)
Coho	0	33	2
Lower Goldsborough			
Chinook	2	22	10
Chum	119 (239)	174 (236)	71 (248)
Coho	0	96	2
Middle Goldsborough			
Chinook	0	0	1
Chum	0	0	35 (84)
Coho	0	5	4
Upper Goldsborough			
Chinook	0	0	0
Chum	0	0	0
Coho	0	0	0
S. Fork Goldsborough			
Chinook	0	0	0
Chum	0	0	0
Coho	0	0	10
Totals			
Chinook	*2*	*22*	*11*
Chum	*150*	*194*	*397*
Coho	*0*	*134*	*18*

4.1.2 Middle Goldsborough Creek RM 2.3-3.4

The 2001 survey effort covered approximately 5,280 ft of stream in Goldsborough Creek immediately upstream of the Project Area during ten surveys (Figures 9 and 10). The first survey was completed on 11 October 2001 after project construction was completed and the stream was returned to its natural channel allowing upstream fish passage. Only one live chinook and one chinook redd were observed upstream from the Project Area (11 October, 2001) (Table A-2). Four live coho were observed during these survey efforts, but no coho

redds. Utilizing the area-under-the-curve methodology and a stream life of ten (10) days for chum salmon, an estimated 84 live chum and 840 total fish days occurred in Middle Goldsborough Creek. In comparison, chum and chinook salmon were not observed above the Project Area during year 2000 surveys (Table 1).

4.1.3 Upper Goldsborough Creek RM 5.8-6.7

The 2001 survey effort covered approximately 5,280 ft of stream in Goldsborough Creek immediately upstream and downstream of the Matlock Road Bridge (near Carmen Road) during ten surveys (Figures 11 and 12). As in 2000, no adult salmonids or redds were observed during the 2001 study period in this survey reach (Table A-3).

4.1.4 South Fork Goldsborough Creek RM 9.9-11.0

The 2001 survey effort covered approximately 5,800 ft of stream in the South Fork Goldsborough Creek (Figures 13 and 14). Ten adult coho were observed in the South Fork Goldsborough Creek during the 2001 study period (Table A-4). No other species or redds were observed. No coho were observed during previous survey years, 1999 and 2000 (Table 1).

4.1.5 Coffee Creek RM 0.0-0.3

The 2001 survey effort covered approximately 1,580 ft of stream in Coffee Creek (Figures 15 and 16). During the 2001 survey effort, 2 live coho, and no coho redds were observed in Coffee Creek (Table A-5). A total of 291 live chum were observed in Coffee Creek (Figure 17). Utilizing the area-under-the-curve methodology and a stream life of ten (10) days for chum salmon, an estimated 814 chum, or 8,140 chum fish days were calculated for Coffee Creek. A total of 61 chum redds were observed in Coffee Creek during the 2001 survey effort. Live chum in Coffee Creek were approximately ten times more numerous in 2001 than in 1999 (n=10) or 2000 (n=9) (Table 1).

4.1.6 Summary

While estimated chum escapement in 2001 is higher than the previous two pre-dam removal survey years, overall recent chum escapement is in a period of decline. Only the 1997 spawning season when an estimated 405 chum salmon spawned downstream of the Project Area was close to recent (1999-2001) escapement levels (Figure 18; Table A-6). From 1994

through 1998, escapement to the Goldsborough Creek basin averaged 1,749 chum (std. deviation = 1,261) (Figure 18; Table A-6). The estimated chum escapement in 2001 was 248 through and downstream of the Project Area and 84 upstream of the Project Area. In addition, one live chinook, and one chinook redd, as well as 14 live coho were observed above the Project Area (i.e., Middle and Upper Goldsborough Creek index reaches). Coho were observed in the South Fork Goldsborough Creek (10 fish), numbers were too low to estimate coho escapement for 2001. No coho escapement has occurred in five of the last nine spawning seasons (1992, 1993, 1996, 1999 and 2000) (Figure 19; Table A-6).

These results indicate that there is post-dam removal salmonid passage above the Project Area by chinook, coho and chum salmon, however, the project may have not been completed early enough in 2001 to allow passage of early returning chum and chinook salmon. Chum salmon appear to be in the initial stages of recolonizing the reaches in Goldsborough Creek upstream from the former dam. Recent spawning surveys conducted in the Goldsborough Creek basin (1999-2001) indicate that chum salmon redds constructed in Lower Goldsborough Creek are susceptible to scour during even moderately high flow events. Scour of eggs and developing alevins can be a significant cause of mortality to salmonids, including chum salmon (Schuett-Hames et al. 2000). Streambed scour in Lower Goldsborough Creek may hinder the recolonization of the Goldsborough Creek basin by chum salmon. Further, based upon the lineal distribution of chum salmon redds, it is hypothesized that many chum salmon returning to Goldsborough Creek are strays from Coffee Creek, thus recolonization of the area may take longer than expected. However, recent record escapement of chum salmon to Southern Puget Sound indicate that post-dam removal surveys should find increasing escapement levels in areas that are now accessible to salmon because of the Goldsborough Creek Restoration Project.

Figure 6. Upstream end of Lower Goldsborough Creek index reach located downstream of the Project Area (RM 0.5-2.2).

Figure 7. Downstream end of Lower Goldsborough Creek index reach located downstream of the Project Area (RM 0.5-2.2).

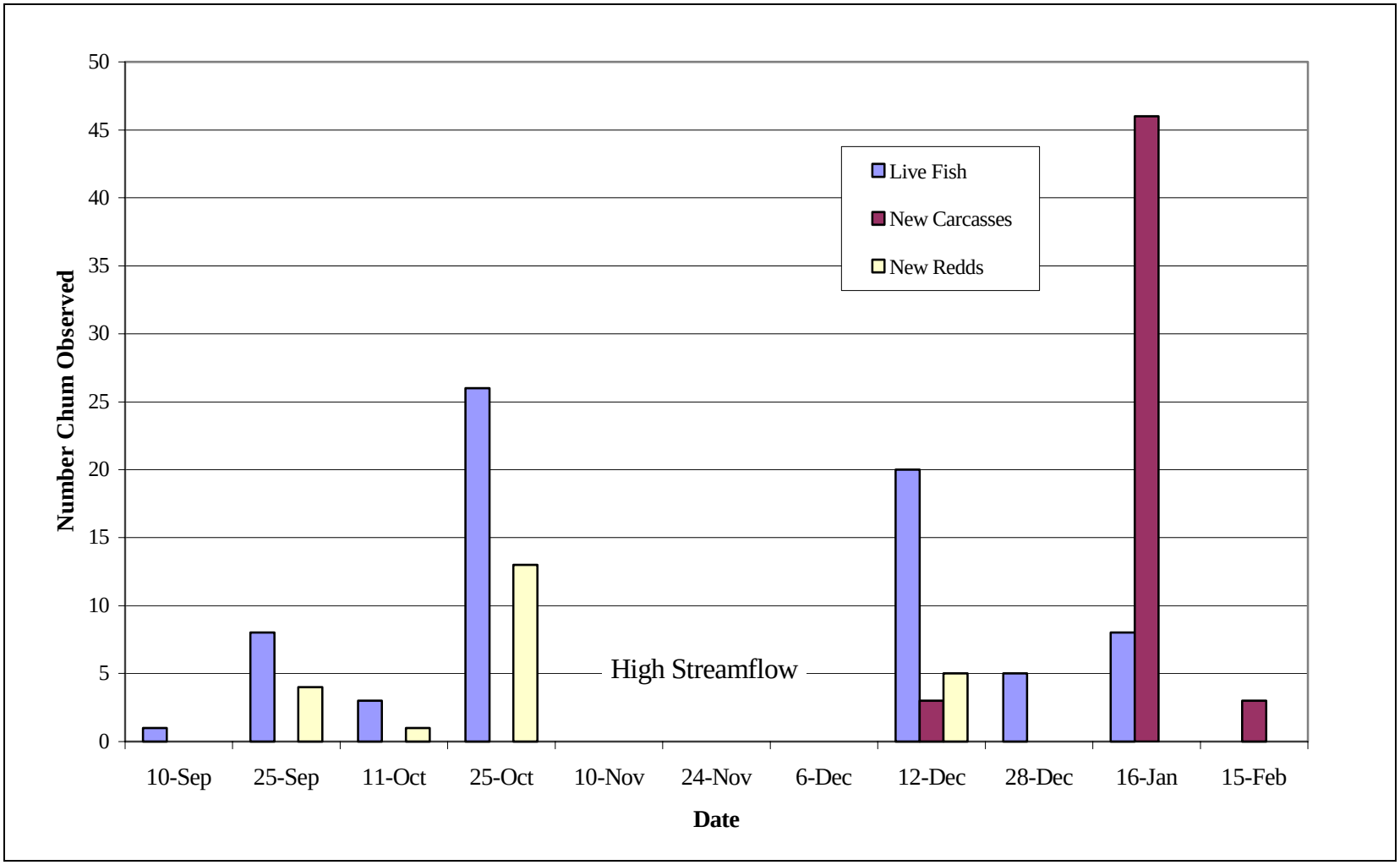

Figure 8. Number of live chum, chum carcasses, and new chum redds observed during spawning surveys conducted in Lower Goldsborough Creek index reach (RM 0.5-2.2), 2001.

Figure 9. Upstream end of Middle Goldsborough Creek index reach located upstream of Project Area (RM 2.4-3.4).

Figure 10. Downstream end of Middle Goldsborough Creek index reach located upstream from Project Area (RM 2.4-3.4).

Figure 11. Upstream end of Upper Goldsborough Creek index reach (RM 5.8-6.7).

Figure 12. Downstream end of Upper Goldsborough Creek index reach (RM 5.8-6.7).

Figure 13. Upstream end of South Fork Goldsborough Creek index reach (RM 9.9-11.0).

Figure 14. Downstream end of South Fork Goldsborough Creek index reach (RM 9.9-11.0).

Figure 15. Upstream end of Coffee Creek index reach (RM 0.0-0.3).

Figure 16. Downstream end of Coffee Creek index reach (RM 0.0-0.3).

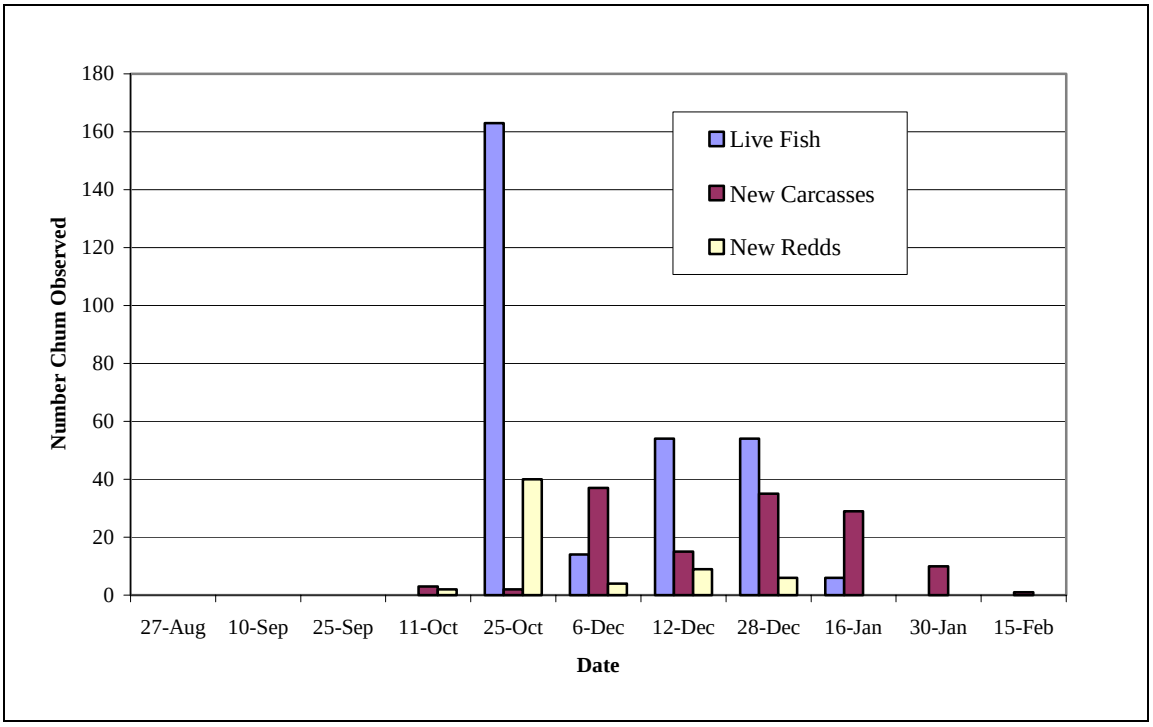

Figure 17. Number of live chum, chum carcasses, and new chum redds observed during spawning surveys conducted in Coffee Creek (RM 0.0-0.3), 2001.

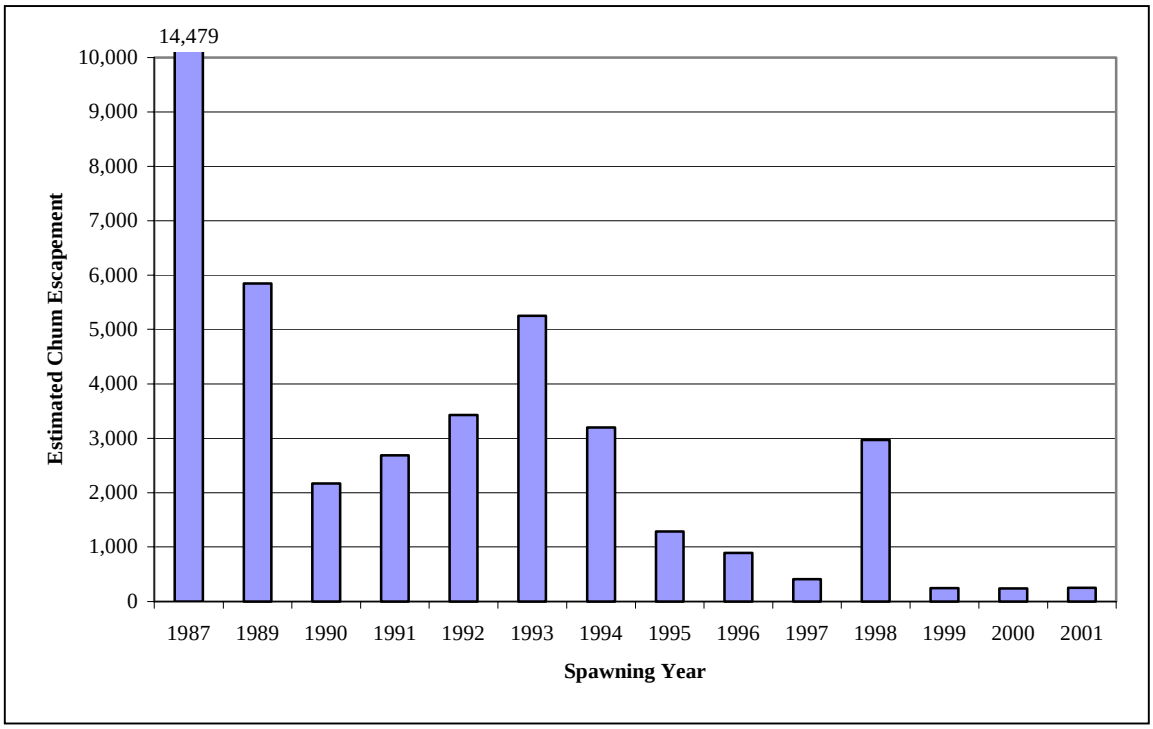

Figure 18. Estimated chum salmon escapement to Goldsborough Creek basin, Washington (RM 0.5-2.2), 1987-2001 (adapted from Seavey 1999).

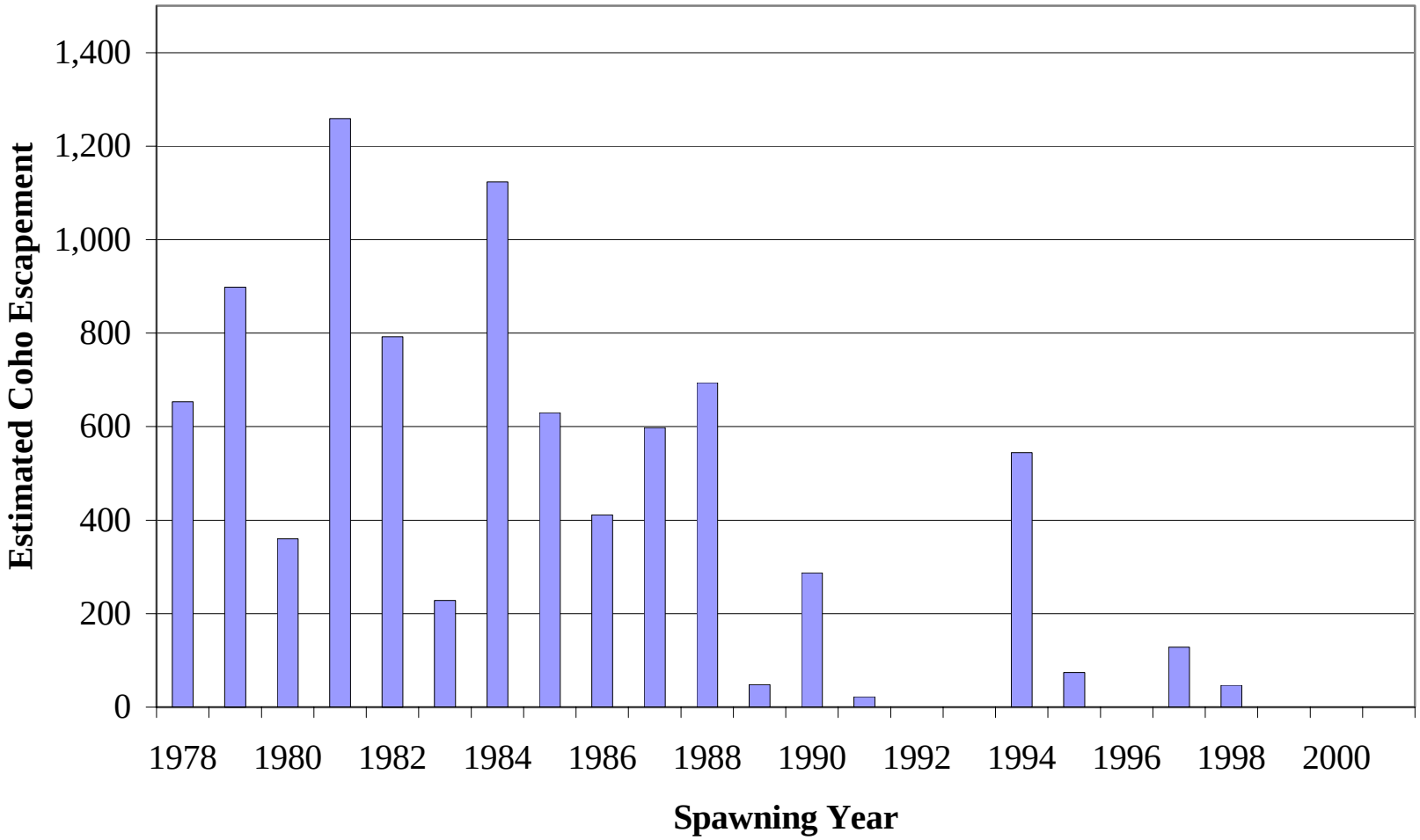

Figure 19. Estimated coho salmon escapement to the South Fork Goldsborough Creek, Washington (RM 9.9-11.0), 1978-2001 (adapted from Seavey 1999).

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APPENDIX A

Raw Data

Biological Monitoring
Goldsborough Creek, Washington
2001 Spawning Survey
Data Report

Table A-1. Date, species, number of live and dead salmon, and number of new redds observed, water temperature (°C), and stage observed in Lower Goldsborough Creek, Washington, (RM 0.5-2.2), 2001.

Date	Species	Live	Dead	Redds	Water Temp. (°C)	Stage (ft)
27-Aug-01	Chinook	0	0	0	13.5	0.57
10-Sep-01	Chinook	3	1	3	13.0	0.50
10-Sep-01	Chum	1			13.0	
25-Sep-01	Chinook	4		2	13.0	0.49
25-Sep-01	Chum	8		4	13.0	
11-Oct-01	Chinook	3		2	9.5	0.58
11-Oct-01	Chum	3		1	9.5	
25-Oct-01	Chum	26		13	9.0	0.87
12-Dec-01	Chum	20	3	5	7.0	1.90
28-Dec-01	Chum	5				1.73
28-Dec-01	Coho	2				
16-Jan-02	Chum	8	46		7.5	1.68
16-Jan-02	Coho		3		7.5	
15-Feb-02	Chum		3		6.5	1.70
15-Feb-02	Coho		1		6.5	
Totals		***83***	***57***	***30***		

Table A-2. Date, species, number of live and dead salmon, and number of new redds, water temperature (°C) observed in Middle Goldsborough Creek, Washington, upstream of the Project Area (RM 2.3-3.4), 2000.

Date	Species	Live	Dead	Redds	Water Temp. (°C)
11-Oct-01	Chinook	1	0	1	
25-Oct-01	Chum	14	1	12	9.5
12-Dec-01	Chum	9	4	2	6.0
28-Dec-01	Chum	4	2	0	7.5
28-Dec-01	Coho	2	1	0	7.5
16-Jan-02	Chum	3	20	0	
16-Jan-02	Coho	2	0	0	
30-Jan-02	Chum	0	1	0	5.0
15-Feb-02	Chum	0	0	0	6.0
Totals		***34***	***29***	***15***	

Table A-3. Date, species, water temperature (°C), number of live and dead salmon, and number of new redds observed in Upper Goldsborough Creek, Washington (RM 5.8-6.7), 2001.

Date	Species	Live	Dead	Redds	Water Temp. (°C)
11-Oct-01	All	0	0	0	9.0
25-Oct-01	All	0	0	0	9.0
28-Dec-01	All	0	0	0	7.0
16-Jan-02	All	0	0	0	6.5
30-Jan-02	All	0	0	0	5.0
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 the South Fork Goldsborough Creek, Washington (RM 9.9-11.0), 2001.

Date	Species	Live	Dead	Redds	Water Temp.(°C)
11-Oct-01	All	0	0	0	
25-Oct-01	All	0	0	0	9.0
10-Nov-01	All	0	0	0	7.5
24-Nov-01	All	0	0	0	7.5
6-Dec-01	Coho	5	0	0	
12-Dec-01	Coho	3	0	0	6.0
28-Dec-01	Coho	2	0	0	8.0
16-Jan-02	All	0	0	0	7.5
30-Jan-02	All	0	0	0	5.0
Totals		***10***	***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), 2001.

Date	Species	Live	Dead	Redds	Water Temp.(°C)
27-Aug-01	Chum	0	0	0	
10-Sep-01	Chum	0	0	0	12.0
25-Sep-01	Chum	0	0	0	
11-Oct-01	Chum	0	3	2	9.0
25-Oct-01	Chum	163	2	40	9.0
6-Dec-01	Coho	0	1	0	
6-Dec-01	Chum	14	37	4	
12-Dec-01	Chum	54	15	9	6.0
28-Dec-01	Chum	54	35	6	4.0
28-Dec-01	Coho	2	0	0	
16-Jan-02	Chum	6	29	0	4.5
30-Jan-02	Chum	0	10	0	5.0
15-Feb-02	Chum	0	1	0	4.0
Totals		***293***	***133***	***61***	

Table A-6. Estimated coho and chum salmon escapement in two reaches of Goldsborough Creek, Washington, 1978-2000.

Year	Estimated Escapement		
	Coho RM 9.9-11.0[1]	Chum RM 0.5-2.2[2]	Chum RM 2.3 –3.4
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	0
2000	0	236	0
2001	0	248	84

[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.