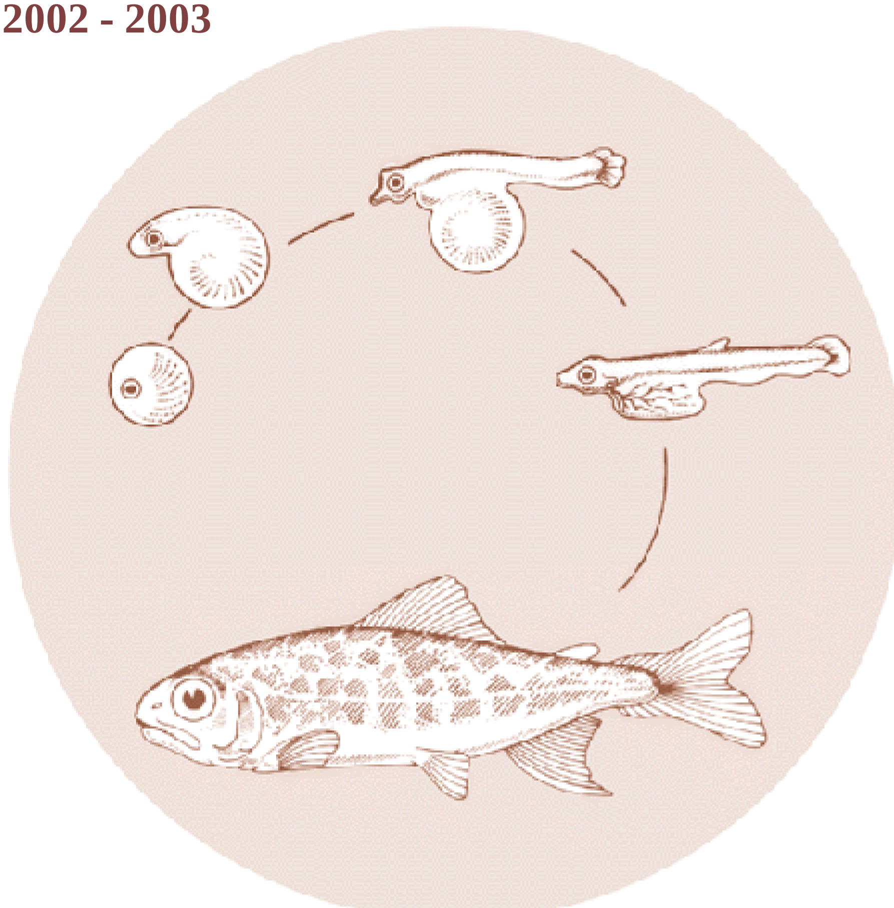
Re-introduction of Lower Columbia River Chum Salmon into Duncan Creek

Annual Report
2002 - 2003



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Re-Introduction of Lower Columbia River Chum Salmon into Duncan Creek
Annual Report for 2003

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Project # 200105300
Bonneville Power Administration
Portland, Oregon

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The National Marine Fisheries Service (NMFS) listed Lower Columbia River chum as threatened under the auspices of the Endangered Species Act (ESA) in March of 1999 (64 FR 14508, March 25, 1999). The listing was in response to reduction in abundance from historical levels of more than half a million returning adults to fewer than 10,000 present day spawners (Johnson *et al.* 1997). Harvest, loss of habitat, changes in flow regimes, riverbed movement and heavy siltation have been largely responsible for the decline of Columbia River chum salmon (Johnson *et al.* 1997). The timing of seasonal changes in river flow and water temperatures is perhaps the most critical factor in structuring the freshwater life history of this species (Johnson *et al.* 1997). This is especially true of the population located directly below Bonneville Dam where hydropower operations can block access to spawning sites, dewater redds, strand fry, cause scour or fill of redds and increase sedimentation of spawning gravels.

Currently, only two main populations are recognized as genetically distinct in the Columbia River, although spawning has been documented in most lower Columbia River tributaries (Johnson *et al.*, 1997; Keller 2001). The first is located in the Grays River (RKm 34) (Grays population), a tributary of the Columbia, and the second is a group of spawners that utilize the Columbia River just below Bonneville Dam (RKm 235) adjacent to Ives Island and in Hardy and Hamilton creeks (Lower Gorge population). A possible third population of mainstem spawners, found in the fall of 1999, were located spawning above the I-205 bridge (approximately RKm 182), this aggregation is referred to as the Woods Landing/Rivershore population or the I-205 group.

Response to the federal ESA listing has been primarily through direct recovery actions: reducing harvest, brood stocking populations at catastrophic risk, habitat restoration (spawning channels) and flow agreements to protect spawning and rearing areas. Both state and federal agencies have built controlled spawning areas. In 1998, the Washington Department of Fish and Wildlife (WDFW) began a chum supplementation program using native stock on the Grays River. This program was expanded in 1999 to include reintroduction into the Chinook River using eggs from the Grays River supplementation program. These eggs are incubated at the Sea Resources Hatchery on the Chinook River and the fry are released at the mouth of the Chinook River.

The recovery strategy for Lower Columbia River (LCR) chum as outlined in Hatchery Genetic Management Plans (HGMP) has three main tasks. First, determine if remnant populations of LCR chum salmon exist in LCR tributaries. Second, if such populations exist, develop stock-specific recovery plans involving habitat restoration including the creation of spawning refugias, supplementation if necessary and a habitat and fish monitoring and evaluation plan. If chum have been extirpated from previously utilized streams, develop re-introduction plans that utilize appropriate genetic donor stock(s) of LCR chum salmon and integrate habitat improvement and fry-to-adult survival evaluations. Third, reduce extinction risks to the Grays River chum salmon population by randomly capturing adults in the basin for use in a supplementation program and reintroduction into the Chinook River basin.

The Duncan Creek project was developed using the same recovery strategy implemented for LCR chum. Biologists with the WDFW and Pacific States Marine Fisheries Commission (PSMFC) identified Duncan Creek as an ideal upriver location below Bonneville Dam for chum re-introduction. It has several attributes that make it a viable location for a re-introduction project: historically chum salmon were present, the creek is low gradient, has numerous springs/seeps, has a low potential for future development and is located close to a donor population of Lower Gorge chum.

The Duncan Creek project has two goals: 1) re-introduction of chum into Duncan Creek by providing off channel high-quality spawning and incubation areas, and 2) to simultaneously evaluate natural re-colonization and a supplementation strategy where adults are collected and spawned artificially at a hatchery. For supplementation, eggs are incubated and the fry reared at the Washougal Hatchery to be released back into Duncan Creek. The tasks associated with re-establishing a naturally self-sustaining population include: 1) removing mud, sand and organics present in four of the creek branches and replace with gravels expected to provide maximum egg-to-fry survival rates to a depth of at least two feet; 2) armoring the sides of these channels to reduce importation of sediment by fish spawning on the margins; 3) planting native vegetation adjacent to the channels to stabilize the banks, trap silt and provide shade; 4) annual sampling of gravel in the spawning channels to detect changes in gravel composition and sedimentation levels. Tasks associated with the second goal of the recovery strategy for Lower Columbia River chum are detailed in The Monitoring and Evaluation Plan for the Duncan Creek Chum Salmon Reintroduction Program (Duncan M&E) (Schroder 2000). Four main questions are used to evaluate the success of this program: 1) what egg-to-fry survival rates are being achieved in the renovated channels, 2) what is the survival of the eggs and fry used in the artificial rearing program in Duncan Creek, 3) what is the survival and spawning ground distribution of adult chum salmon produced from the spawning channels and the artificial rearing program, and 4) what is the straying rate of non-program chum salmon into Duncan Creek. The monitoring portion of the Duncan M&E includes documenting and monitoring the physical attributes of the channels. These physical attributes include, but are not limited to, gravel composition, sedimentation load, dissolved oxygen (DO) levels, vertical hydraulic gradients and water temperatures in the hyporheic zone, and flow.

Evaluation and Monitoring of Re-Introduction Efforts

Currently, two methods of re-introduction are being simultaneously evaluated at Duncan Creek. Natural re-colonization is occurring by introducing adult chum salmon from the Lower Gorge (LG) population into Duncan Creek and allowing them to naturally reproduce. The supplementation strategy required adults to be collected and artificially spawned, incubated, reared, and released at the mouth of Duncan Creek. All eggs from the artificial crossings at Washougal Hatchery were incubated and the fry reared to release size at the hatchery. Remote Site Incubators (RSI) to incubate eggs at Duncan Creek, while not ruled out for use in future years, were not used in 2002.

Part I: Duncan Creek Chum Salmon Hatchery Program

Introduction

The goal of the Duncan Creek chum salmon hatchery program at Washougal Hatchery is to preserve genetic diversity within the LG population and provide a source of chum salmon for reintroduction into Duncan Creek and other potential spawning sites. This is accomplished by collecting sufficient numbers of broodstock to maintain genetic diversity and collecting those adults over the entire run period. To maintain genetic diversity, a minimum of 35 pairs are spawned using factorial crosses. Historical run timing records were consulted to calculate the number needed weekly to maintain natural run timing. Eventually, all fish needed for this program should be available by operating an adult trap at the mouth of Duncan Creek. As in 2001, fish used in 2002 were collected from known nearby spawning areas of the LG population. Methods used to spawn, incubate, and track various biological parameters from adult collection through fry emergence and ponding are detailed in Appendix 1 of the Duncan M&E. These methods are similar to those presented in the Summer Chum Conservation Initiative (WDFW and Point no Point Treaty Tribes 2000). Measurements of phenotypic traits collected on females used in the supplementation program will also provide the data needed to produce the predictive regression formulas of fecundity for estimating the egg-to-fry survival rates of females that spawned naturally in the channels. This is the second year of the hatchery program evaluation.

Methods

Adult Collection

Personnel from WDFW and PSMFC collected adults from several known spawning locations using tangle nets. Adults were captured as they staged and spawned in shallow water (< 10’ deep) using a 200’ x 12’ x 2” “floating” tangle net. These nets tangle adults by their maxillary bones and teeth not by the opercula as would happen in conventional gillnetting. Adults selected for the supplementation program at Washougal Hatchery were placed into a fish tube. The fish tubes were three feet long sections of 10” diameter PVC pipe, perforated with several one and a half inch holes, and equipped with removable end pieces. The sex of the fish, date, time and location of capture was recorded with a pencil on each tube. Tanker trucks transported fish, while they were still in the tubes, to the hatchery. Three tanker trucks were used for the project depending on expected number of adults needing to be moved. They have capacities of 400, 1,500 or 2,000 gallons, and are equipped with an oxygen supply. The 400-gallon tanker truck was used for the majority of the 2002 season to transport adults.

Holding, Spawning and Rearing

Upon arrival at the hatchery, tubed fish were placed into an adult holding pond. The tubes were placed on the bottom of the adult pond. Fish were re-checked at the hatchery for spawning readiness based on the observed state of ripeness at time of capture. Once the number of ripe females had been determined, the number of males needed to perform the factorial cross were calculated. Males were checked for ripeness and the first available ripe males were used for spawning.

Protocols outlined in Appendix 1 of the Duncan M&E were followed to spawn, incubate and track various biological parameters from adult collection through fry emergence and ponding. These methods are similar to those presented in the Summer Chum Conservation Initiative (WDFW and PNPTT, 2000). A brief summary of these methods is presented below.

Ripe females and males were killed with a sharp blow to the head and a gill arch was cut to bleed the females. Each fish was labeled by stapling a square of Rite-in-the-Rain paper with its assigned number to the opercle. Fish were numbered consecutively (F-1, F-2, F-3, M-1, M-2, M-3, etc) throughout the spawning season. Before any eggs were removed, each female's weight, fork and mid-eye-to-hypural (MEtH) lengths were recorded. A conditional assessment (ranging from excellent to poor) based on fin condition, scale loss and fungal infection was recorded for each adult. Females that may have already spawned (spent) or appeared to have partially spawned were also noted. Each female was wiped down to remove contaminants and water prior to egg collection. Eggs were extracted using a spawning knife and collected in a dry plastic bucket. Milt was collected only after all females in the cross had been spawned. Males were also wiped down prior to spawning and milt was expressed into a clean, dry container. Total egg mass weight (weight of green eggs minus ovarian fluid, 0.1 g accuracy) and mean green egg weight (0.01 g accuracy) were recorded for each female. Using these two values, an estimate of fecundity was calculated. Biological sampling of each fish included scale samples, pathogen samples, DNA samples and GSI samples. Five additional eggs were collected from each female to be water hardened and individually weighed to the nearest mg.

Factorial crosses were used whenever numbers of ripe males and females allowed. Each female's eggs were divided into the number of lots needed by weight. Milt was divided equally using a graduated syringe. No backup males were needed when performing factorial crosses since the males can backup each other, if a one-to-one cross occurred another male would be needed as the backup. After the gametes were mixed, water added, and backup milt applied, the eggs were allowed to sit for two minutes. Individual lots were then recombined, if needed, and placed into a Heath incubation tray. Eggs were exposed to a PVP solution for 60 minutes in the Heath tray before being moved into incubation racks. Each Heath tray was labeled with the females' number and spawn date.

After the eggs reached the eyed stage (~ 680 ^{o} F Temperature Units (TU)), they were shocked, and non-viable eggs were removed and enumerated by hand. A total weight of eyed eggs was recorded and five sub-samples were weighed and hand counted to calculate estimates of total eyed eggs. These estimates were then used to calculate a mean number of eyed eggs with 95% confidence intervals. This mean number of eyed eggs, plus the number of non-viable eggs removed, provided a more accurate estimate of fecundity. Folded Vexar, which prevents yolk sac deformations and maximizes yolk material utilization rates, was placed in each Heath tray before returning the eggs after shocking and picking.

Fish liberated from a recovery program need to be marked for identification upon recovery (Schroder et al. 1995). Marking also allows comparisons to be made between different treatment groups. All fish released under this program were thermally marked. Thermal marks are created by manipulating temperatures during the stages between eyed and yolk absorption (Volk et al. 1990, 1994 and 1999). Each time the water temperature is dropped by 2-4^{o} C a distinctive black band is deposited in the microstructure of a developing otolith (Figure 1). Exposure to chilled water for periods of 8 to 48 hours will essentially create bar codes on the otoliths that can be read. The bar codes will be determined and a schedule for chilled water applications by personnel in the WDFW's Otolith Lab. Hatchery personnel applied the treatments, and voucher samples were taken to determine mark quality and form.

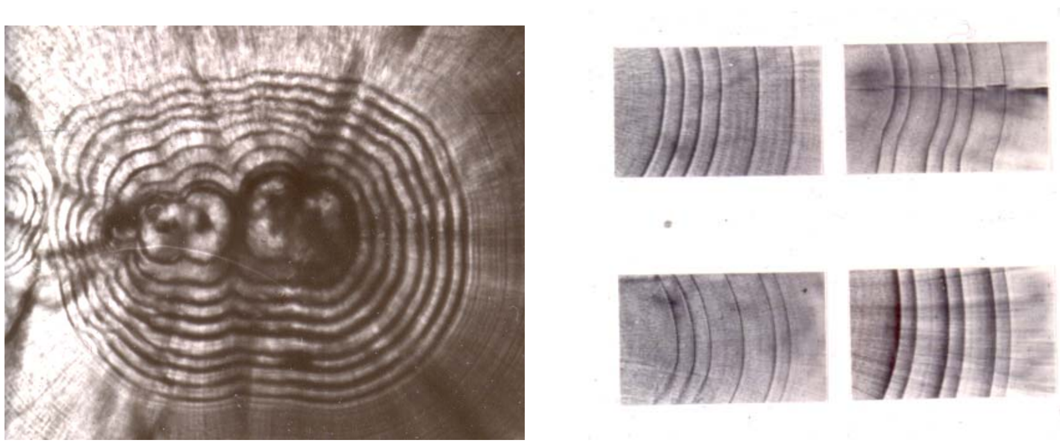

Figure 1. Photomicrographs showing the general appearance of thermally marked salmonid otoliths.

Mortalities and abnormalities were enumerated and recorded for each female when the fish were ponded. These mortality numbers, combined with those removed at the eyed stage, were used to calculate egg-to-fry survival rates. At ~ 1,500 ^{o}F TU five to ten fry from each Heath tray were visually inspected to ascertain the width of yolk still visible on each fry. When only a small slit was observed, K_D values (Bams 1970) were calculated on 10 to 20 individuals from the tray.

$$K_D = (10\sqrt[3]{\text{Wt in mg}}) / \text{Fork Length in mm}$$

When the average of these individual K_D values was around 1.9 the fry were ready to be ponded. K_D values were calculated again using five fry from each tray when they were ponded.

All chum salmon recovery projects at WDFW hatcheries release fed fry at 1 to 1.5 grams or 50 to 55 mm in fork length. Such fry will likely realize significant survival advantages and not suffer any loss in their osmo-regulatory capacity. This size standard will be followed until data specific to a release location or stock indicates an alternative size may have an increased survival potential (Jim Ames et al. 2000).

The fry were divided into rearing vessels and held at accepted rearing densities and flow index values. Fry were fed a semi-moist diet with no fines as mash diets are known to produce gill abrasions in chum fry. Once the fish were actively feeding they received a daily ration of 3% of their body weight. This ration was spread out over the day, feeding at least once every hour. Weekly weight measurements were taken to adjust the ration level. Feed size increased as the fish grew, but pellet size never exceeded one-fortieth of fork length of the reared fish. Mortalities were enumerated and removed daily. Rearing vessels were cleaned at least once per week. Several environmental parameters were measured and recorded during the rearing period. Flow rates and DO levels were measured and recorded weekly. Water temperatures were recorded twice daily in the morning and after the last feeding, with a hand-held thermometer. Daily rainfall and ambient air temperatures were also recorded daily.

Fry were released at night on an outgoing tide. Feeding ceased two or three days prior to release, and fifty random fish from each rearing vessel were measured, fork length to the nearest mm, and individually weighed to the nearest 0.01 g. These data were used to produce mean weights, lengths, condition (K) values, coefficient of variation statistics for each measured parameter, and frequency distributions for lengths and weights.

Results

Broodstock Collection and Holding

A total of 171 adults (87 males and 84 females) were taken to Washougal Hatchery for spawning (Table 1). They were transported, in the PVC holding tubes to the hatchery, where they were placed into an asphalt lined holding pond. Three adults died while being held, one female and two males.

In addition to the 171 adults, on December 7, 2002, 13 adults (four males and nine females) were removed from the north spawning channel at Duncan Creek and brought to Washougal Hatchery to be spawned. This was done in response to extremely low water levels in the channels. The justification for removing these adults from the spawning channels is discussed in detail under **Part III: Natural Spawning**. Adults removed from the channels and spawned at Washougal Hatchery are identified in the following tables as channel female (CF) and channel male (CM).

Table 1. Date of Capture and Origin of Adults used at Washougal Hatchery, 2002.

Date	Location	Number Adult Chum Seined	# Taken to Washougal Hatchery Male	# Taken to Washougal Hatchery Female
11/6	Hamilton Slough	23	3	2
11/13	Hamilton Bay/Pocket	34	5	5
11/18	Hamilton Bay/Pocket	48	15	15
11/25	Hamilton Bay/Pocket	127	8	8
12/5	Hamilton Bay/Pocket	305	24	25
12/5	Top of Pierce Island	54	6	4
12/9	Hamilton Bay/Pocket	138	11	11
12/9	Top of Pierce Island	72	4	2
12/9	Bottom of Ives Island	24	1	1
12/16	Hamilton Bay/Pocket	97	10	11
	Total	922	87	84

Spawning

The spawning protocol outlined in the Duncan M&E Appendix 1 (Schroder 2000) was followed with the following exception: five egg samples for mean water hardened green egg weights were only taken on the first 19 females spawned. Spawning occurred seven times between November 12 and December 17 (Table 2). The number of females spawned on a given day ranged from two (the first spawn) to 29 (December 5). Green females were intentionally excluded during brood stock selection. Most females were spawned within a few days of capture, the number of days between the two events ranged from one to six, averaging just over one day. Males were selected for spawning based on the number of ripe females and a first into hatchery, first used basis. Table 3 details information on capture location/date and spawning date as well as biological data collected on males used for spawning. Most males were also spawned within a few days of capture, the number of days between the two events ranged from one to six, averaging just over one day.

The age composition of females taken to Washougal Hatchery was dominated by age-4 fish, 63.9% versus 32.6% for age-3 and 2.4% for age-5 (Figure 2). Similarly, the male age composition was predominately age-4 fish, 57.6% versus 41.2% for age-3 and 1.2% for age-5 (Figure 2).

Fork lengths for age-3 females ranged from 618 mm to 764 mm, averaging 677.9 mm. Age-4 females ranged from 613 mm to 824 mm, averaging 734.4 mm, and age-5 females ranged from 720 mm to 790mm, averaging 755.0mm (Figure 3). Fork lengths for age-3 males ranged from 613 mm to 814 mm, averaging 739.5 mm. Age-4 males ranged from 634 mm to 927 mm, averaging 799.4 mm, and the one age-5 male measured 840 mm (Figure 4). Whole body weight for age-3 females ranged from 2,130.5g to 5,067.5 g, averaging 3,459.3 g. Age-4 female whole body weight ranged from 3,289.5 g to 7,476.0 g, averaging 4,831.3 g, age-5 female whole body weight ranged from 4,039.0 g to 5,384.0 g, averaging 4,711.5 g.

The biological information collected on each female used in the supplementation program is presented in (Table 2). Fecundity estimates were made on females that had reproductive effort values (total egg mass/body weight) that were greater than 16%. These estimates showed that, at the green egg stage age-3 females had fecundities that ranged from 1,838 to 3,569, and averaged 2,805. The fecundities of four-yr-old fish ranged from 2,489 to 4,333, and averaged 3,131 eggs. Only one age-5 female had a reproductive value >16% and its fecundity was 3,164. An estimated total of 249,053 green eggs were collected during the spawning season. This total includes eggs taken from females collected from the Duncan Creek north spawning channel on December 7.

Table 2. Location and Date of Capture, Date of Spawning, Factorial Crosses, Condition, Weight, Fork & MEtH Lengths (mm), Age, Green Egg Mass Weight, Mean Green Egg Weight and Estimated Fecundity of Female Chum Spawned at Washougal Hatchery, 2002.

Female #	Location of capture	Date of capture	Date of Spawning	Factorial Spawning, Primary Male listed first	Condition of Fish at Spawning	Whole Body Weight (g)	Fork Length (mm)	MEtH Length (mm)	Age	Green Egg Mass Weight (g)	Mean Green Egg Weight (g)	Estimated Fecundity
F-1	Hamilton Slough	11/06/02	11/12/02	M-1, 2	Good	5,536.0	760	605	4	959	0.3021	3,174
F-2	Hamilton Slough	11/06/02	11/12/02	M-2, 1	Dead	7,476.0	824	630	4	977	0.2966	3,294
F-3	Hamilton Bay/Pocket	11/13/02	11/15/02	M-3, 4, 5	Excellent	5,390.5	760	612	4	1,008	0.3568	2,825
F-4	Hamilton Bay/Pocket	11/13/02	11/15/02	M-4, 3, 5	Good	4,053.0	758	615	4	420	0.2667	1,575
F-5	Hamilton Bay/Pocket	11/13/02	11/15/02	M-5, 4, 3	Excellent	5,007.5	741	600	4	822	0.3122	2,633
F-6	Hamilton Bay/Pocket	11/13/02	11/15/02	M-6, 7	Good	3.895.0	613	536	4	674	0.2708	2,489
F-7	Hamilton Bay/Pocket	11/13/02	11/15/02	M-7, 6	Excellent	4,499.5	713	575	4	680	0.2647	2,569
F-8	Hamilton Bay/Pocket	11/18/02	11/19/02	M-8, 9, 10	Good	5,560.5	765	602	4	820	0.2652	3,092
F-9	Hamilton Bay/Pocket	11/18/02	11/19/02	M-9, 8, 10	Good	5,331.5	740	611	4	1,048	0.2857	3,668
F-10	Hamilton Bay/Pocket	11/18/02	11/19/02	M-10, 9, 8	Good	6,058.0	775	607	4	1,104	0.2879	3,835
F-11	Hamilton Bay/Pocket	11/18/02	11/19/02	M-11, 12	Good	5,510.0	737	600	4	930	0.2875	3,235
F-12	Hamilton Bay/Pocket	11/18/02	11/19/02	M-12, 11	Good	4,055.0	711	578	4	588	0.2389	2,461
F-13	Hamilton Bay/Pocket	11/18/02	11/19/02	M-13, 14, 15	Good	5,842.0	770	625	4	1,078	0.2793	3,860
F-14	Hamilton Bay/Pocket	11/18/02	11/19/02	M-14, 13, 15	Good	4,336.5	774	582	4	913	0.2696	3,387
F-15	Hamilton Bay/Pocket	11/18/02	11/19/02	M-15, 14,13	Good	3,392.0	676	545	3	620	0.2174	2,852
F-16	Hamilton Bay/Pocket	11/18/02	11/19/02	M-16, 17	Good	4,464.0	700	505	4	762	0.2556	2,982
F-17	Hamilton Bay/Pocket	11/18/02	11/19/02	M-17, 16	Good	3,394.5	678	555	3	706	0.2552	2,767
F-18	Hamilton Bay/Pocket	11/18/02	11/20/02	M-18, 19, 20	Good	5,940.5	771	625	4	982	0.2700	3,637
F-19	Hamilton Bay/Pocket	11/18/02	11/20/02	M-19, 18, 20	Good	5,628.0	752	595	4	1,068	0.3000	3,560
F-20	Hamilton Bay/Pocket	11/18/02	11/20/02	M-20, 18, 19	Good	5,635.5	771	624	4	1,040	0.2400	4,333
F-21	Hamilton Bay/Pocket	11/18/02	11/20/02	M-21, 22	Good	3,791.0	695	566	4	662	0.2240	2,955
F-22	Hamilton Bay/Pocket	11/18/02	11/20/02	M-22, 22	Good	4,387.5	705	555	4	878	0.2394	3,668
F-23	Hamilton Bay/Pocket	11/25/02	11/26/02	M-23, 24	Good	4,948.0	688	565	4	576	0.2429	2,372
F-24	Hamilton Bay/Pocket	11/25/02	11/26/02	M-24, 23	Good	2,574.5	645	537	3	146	0.2435	600*
F-25	Hamilton Bay/Pocket	11/25/02	11/26/02	M-25, 26	Good	4,380.0	745	608	3	814	0.2480	3,282
F-26	Hamilton Bay/Pocket	11/25/02	11/26/02	M-26, 25	Good	4,727.5	730	590	4	874	0.2826	3,093
F-27	Hamilton Bay/Pocket	11/25/02	11/26/02	M-27, 28	Good	3,621.0	678	565	4	724	0.2484	2,915
F-28	Hamilton Bay/Pocket	11/25/02	11/26/02	M-28, 27	Good	4,701.5	763	617	4	924	0.2846	3,246
F-29	Hamilton Bay/Pocket	11/25/02	11/26/02	M-29, 30	Good	4,039.0	720	594	5	570	0.3240	1,759
F-30	Hamilton Bay/Pocket	11/25/02	11/26/02	M-30, 29	Good	4,055.0	724	593	4	718	0.2640	2,720
F-31	Hamilton Bay/Pocket	12/05/02	12/06/02	M-31, 32	Excellent	4,787.0	754	604	4	792	0.2607	3,038
F-32	Hamilton Bay/Pocket	12/05/02	12/06/02	M-32, 31	Excellent	4,823.0	730	581	4	712	0.2789	2,552
F-33	Hamilton Bay/Pocket	12/05/02	12/06/02	M-33, 34	Excellent	5,067.5	730	593	3	794	0.2607	3,045
F-34	Hamilton Bay/Pocket	12/05/02	12/06/02	M-34, 33	Good	3,088.5	685	544	3	464	0.2172	2,136
F-35	Hamilton Bay/Pocket	12/05/02	12/06/02	M-35, 36	Excellent	2,510.0	660	528	3	570	0.2205	2,585
F-36	Hamilton Bay/Pocket	12/05/02	12/06/02	M-36, 35	Excellent	6,230.5	778	625	4	890	0.2407	3,697
F-37	Hamilton Bay/Pocket	12/05/02	12/06/02	M-37, 38	Good	2,951.0	658	532	3	722	0.2462	2,933
F-38	Hamilton Bay/Pocket	12/05/02	12/06/02	M-38, 37	Good	3,739.5	694	565	3	636	0.2250	2,827

* These fish were described as partially spawned out at the time of spawning.

Table 2. Continued.

Female #	Location of capture	Date of capture	Date of Spawning	Factorial Spawning, Primary Male listed first	Condition of Fish at Spawning	Whole Body Weight (g)	Fork Length (mm)	MEtH Length (mm)	Age	Green Egg Mass Weight (g)	Mean Green Egg Weight (g)	Estimated Fecundity
F-39	Hamilton Bay/Pocket	12/05/02	12/06/02	M-39, 40	Excellent	4,305.0	706	576	3	710	0.2136	3,323
F-40	Hamilton Bay/Pocket	12/05/02	12/06/02	M-40, 39	Excellent	4,251.0	695	567	3	732	0.2353	3,111
F-41	Hamilton Bay/Pocket	12/05/02	12/06/02	M-41, 42	Good	3,273.5	627	510	3	480	0.2276	2,109
F-42	Hamilton Bay/Pocket	12/05/02	12/06/02	M-42, 41	Excellent	5,685.5	767	616	4	904	0.2880	3,139
F-43	Hamilton Bay/Pocket	12/05/02	12/06/02	M-43, 45, 46	Excellent	5,856.5	780	625	4	854	0.3200	2,669
F-44	Hamilton Bay/Pocket	12/05/02	12/06/02	M-45, 46, 43	Excellent	4,443.0	715	582	4	870	0.3000	2,900
F-45	Hamilton Bay/Pocket	12/05/02	12/06/02	M-45, 46	Excellent	3,923.0	680	558	3	672	0.2333	2,880
F-46	Hamilton Bay/Pocket	12/05/02	12/06/02	M-46, 45	Good	3,714.5	674	540	3	565	0.2267	2,493
F-47	Hamilton Bay/Pocket	12/05/02	12/06/02	M-47, 48	Excellent	6,115.0	756	617	4	972	0.2733	3,556
F-48	Hamilton Bay/Pocket	12/05/02	12/06/02	M-48, 47	Excellent	4,396.0	723	580	4	344	0.2542	1,353*
F-49	Hamilton Bay/Pocket	12/05/02	12/06/02	M-49, 50	Excellent	3,225.0	642	520	3	634	0.2375	2,669
F-50	Hamilton Bay/Pocket	12/05/02	12/06/02	M-50, 49	Good	3,866.0	685	565	3	822	0.2303	3,569
F-51	Hamilton Bay/Pocket	12/05/02	12/06/02	M-51, 52	Good	4,344.5	735	592	4	856	0.2769	3,091
F-52	Hamilton Bay/Pocket	12/05/02	12/06/02	M-52, 51	Good	5,384.0	790	637	5	998	0.3154	3,164
F-53	Hamilton Bay/Pocket	12/05/02	12/06/02	M-53, 54	Good	3,026.0	628	525	3	488	0.2367	2,062
F-54	Hamilton Bay/Pocket	12/05/02	12/06/02	M-54, 53	Good	5,023.5	725	593	4	886	0.2559	3,463
F-55	Hamilton Bay/Pocket	12/05/02	12/06/02	M-55, 56, 57	Good	4,780.0	735	583	4	864	0.2720	3,176
F-56	Top of Pierce Island	12/05/02	12/06/02	M-56, 55, 57	Good	4,880.5	745	592	4	850	0.2793	3,043
F-57	Top of Pierce Island	12/05/02	12/06/02	M-57, 55, 56	Good	3,753.5	708	573	3	688	0.2038	3,375
F-58	Top of Pierce Island	12/05/02	12/06/02	M-58, 59	Excellent	3,910.5	684	560	4	632	0.2393	2,641
F-59	Top of Pierce Island	12/05/02	12/06/02	M-59, 58	Good	3,799.0	689	559	4	776	0.2481	3,127
F-60	Hamilton Bay/Pocket	12/09/02	12/10/02	M-60, 61	Good	4,764.5	758	649	4	844	0.3276	2,576
F-61	Hamilton Bay/Pocket	12/09/02	12/10/02	M-61, 60	Good	3,748.0	701	578	3	634	0.2593	2,445
F-62	Hamilton Bay/Pocket	12/09/02	12/10/02	M-62, 63	Fair	2,130.5	618	554	3	438	0.2383	1,838*
F-63	Hamilton Bay/Pocket	12/09/02	12/10/02	M-63, 62	Excellent	4,107.5	721	583	4	816	0.2739	2,979
F-64	Hamilton Bay/Pocket	12/09/02	12/10/02	M-64, 65	Excellent	3,096.5	657	586	3	570	0.2421	2,354
F-65	Hamilton Bay/Pocket	12/09/02	12/10/02	M-65, 66	Excellent	5,135.5	750	595	NR	828	0.2862	2,893
F-66	Hamilton Bay/Pocket	12/09/02	12/10/02	M-66, 67	Excellent	4,001.5	694	621	4	722	0.2583	2,795
F-67	Hamilton Bay/Pocket	12/09/02	12/10/02	M-67, 68	Good	3,253.5	694	568	3	396	0.2593	1,527*
F-68	Hamilton Bay/Pocket	12/09/02	12/10/02	M-68, 69, 70, 74	Excellent	3,357.5	661	541	3	518	0.2259	2,293
F-69	Hamilton Bay/Pocket	12/09/02	12/10/02	M-69, 68, 70, 74	Good	2,679.5	634	522	4	550	0.2538	2,167
F-70	Hamilton Bay/Pocket	12/09/02	12/10/02	M-70, 68, 69, 74	Excellent	5,024.5	758	613	4	726	0.2704	2,685
F-71	Top of Pierce Island	12/09/02	12/10/02	M-71, 72, 73, 75	Good	4,704.5	745	615	4	912	0.3080	2,961
F-72	Top of Pierce Island	12/09/02	12/10/02	M-72, 73, 71, 75	Good	5,443.0	779	627	4	914	0.2964	3,083
F-73	Bottom of Ives Island	12/09/02	12/10/02	M-73, 71, 72, 75	Excellent	4,496.0	720	599	4	810	0.2429	3,335
F-74	Hamilton Bay/Pocket	12/16/02	12/17/02	M-77, 78	Fair	4,004.0	700	582	4	534	0.2783	1,919
F-75	Hamilton Bay/Pocket	12/16/02	12/17/02	M-78, 77	Excellent	4,859.0	727	591	4	754	0.2952	2,554
F-76	Hamilton Bay/Pocket	12/16/02	12/17/02	M-77, 78	Good	5,357.0	754	619	4	924	0.2742	3,370

* These fish were described as partially spawned out at the time of spawning.

Table 2. Continued.

Female #	Location of capture	Date of capture	Date of Spawning	Factorial Spawning, Primary Male listed first	Condition of Fish at Spawning	Whole Body Weight (g)	Fork Length (mm)	MeTH Length (mm)	Age	Green Egg Mass Weight (g)	Mean Green Egg Weight (g)	Estimated Fecundity
F-77	Hamilton Bay/Pocket	12/16/02	12/17/02	M-78, 77	Fair	4,865.0	751	586	4	432	0.2524	1,712
F-78	Hamilton Bay/Pocket	12/16/02	12/17/02	M-79, 80	Excellent	4,122.5	695	553	3	622	0.2577	2,414
F-79	Hamilton Bay/Pocket	12/16/02	12/17/02	M-80, 79	Excellent	4,983.5	774	637	4	576	0.2727	2,112
F-80	Hamilton Bay/Pocket	12/16/02	12/17/02	M-81, 82	Good	4,568.5	731	586	4	722	0.2485	2,906
F-81	Hamilton Bay/Pocket	12/16/02	12/17/02	M-82, 81	Excellent	2,653.0	639	514	3	310	0.2500	1,240*
F-82	Hamilton Bay/Pocket	12/16/02	12/17/02	M-83, 84	Good	3,374.0	764	530	3	324	0.2130	1,521*
F-83	Hamilton Bay/Pocket	12/16/02	12/17/02	GREEN FEMALE	Excellent	4,113.0	679	554	4	----	----	------
F-84	Hamilton Bay/Pocket	12/16/02	12/17/02	M-84, 83	Fair	3,231.5	659	536	3	590	0.2297	2,568
CF-1	From N. Channel		12/07/02		Fair	2,475.6	635	515	3	Only one egg in this female		
CF-2	From N. Channel		12/07/02	CM-2, 3, 4	Good	4,089.5	724	588	4	856	0.2677	3,197
CF-3	From N. Channel		12/07/02	CM-2, 3, 4	Good	4,742.5	755	610	4	710	0.2634	2,695
CF-4	From N. Channel		12/07/02	CM-2, 3, 4	Good	3,958.0	680	545	3	278	0.2286	1,216
CF-5	From N. Channel		12/07/02	CM-2, 3, 4	Good	1,564.0	620	500	3	212	0.2108	1,006
CF-6	From N. Channel		12/07/02	CM-2, 3, 4	Good	3,792.0	711	573	4	368	0.2821	1,304
CF-7	From N. Channel		12/07/02	CM-2, 3, 4	Good	3,914.5	725	570	4	476	0.2649	1,797
CF-8	From N. Channel		12/07/02	CM-2, 3, 4	Good	3,934.5	730	598	3	1,036	0.2700	3,837
CF-9	From N. Channel		12/07/02	CM-2, 3, 4	Good	4,032.5	740	595	4	1,008	0.3161	3,189

*These fish were described as partially spawned out at the time of spawning.

Table 3. Location and Date of Capture, Date of Spawning, Factorial Crosses, Condition, Weight, Fork & MEtH Lengths (mm) and Age of Male Chum Spawned at Washougal Hatchery, 2002.

Male #	Location of Capture	Date of Capture	Date of Spawning	Condition at Spawning	Fork Length (mm)	MEtH (mm)	Whole Body Weight (g)	Age	Used as Primary Male with Female #
M-1	Hamilton Slough	11/6/02	11/12/02	Fair	709	545	3,746.0	3	F-1
M-2	Hamilton Slough	11/6/02	11/12/02	Excellent	758	570	4,510.0	3	F-2
M-3	Hamilton Bay/Pocket	11/13/02	11/15/02	Good	739	572	4,269.5	4	F-3
M-4	Hamilton Bay/Pocket	11/13/02	11/15/02	Good	824	635	7,083.0	4	F-4
M-5	Hamilton Bay/Pocket	11/13/02	11/15/02	Excellent	776	603	5,060.5	4	F-5
M-6	Hamilton Bay/Pocket	11/13/02	11/15/02	Good	927	622	6,646.5	4	F-6
M-7	Hamilton Bay/Pocket	11/13/02	11/15/02	Excellent	801	607	6,795.0	4	F-7
M-8	Hamilton Bay/Pocket	11/18/02	11/19/02	Good	781	582	6,288.5	3	F-8
M-9	Hamilton Bay/Pocket	11/18/02	11/19/02	Good	740	570	4,722.5	3	F-9
M-10	Hamilton Bay/Pocket	11/18/02	11/19/02	Good	805	630	5,872.0	4	F-10
M-11	Hamilton Bay/Pocket	11/18/02	11/19/02	Good	718	562	4,508.0	4	F-11
M-12	Hamilton Bay/Pocket	11/18/02	11/19/02	Good	763	594	4,824.5	3	F-12
M-13	Hamilton Bay/Pocket	11/18/02	11/19/02	Good	690	543	3,789.5	3	F-13
M-14	Hamilton Bay/Pocket	11/18/02	11/19/02	Good	808	620	6,460.5	4	F-14
M-15	Hamilton Bay/Pocket	11/18/02	11/19/02	Good	858	665	8,320.5	4	F-15
M-16	Hamilton Bay/Pocket	11/18/02	11/19/02	Good	883	647	9,028.0	4	F-16

Table 3. Continued.

Male #	Location of Capture	Date of Capture	Date of Spawning	Condition at Spawning	Fork Length (mm)	MEtH (mm)	Whole Body Weight (g)	Age	Used as Primary Male with Female #
M-17	Hamilton Bay/Pocket	11/18/02	11/19/02	Good	778	581	6,200.5	3	F-17
M-18	Hamilton Bay/Pocket	11/18/02	11/20/02	Good	791	668	6,156.5	4	F-18
M-19	Hamilton Bay/Pocket	11/18/02	11/20/02	Good	733	578	4,694.0	3	F-19
M-20	Hamilton Bay/Pocket	11/18/02	11/20/02	Good	814	622	6,009.0	4	F-20
M-21	Hamilton Bay/Pocket	11/18/02	11/20/02	Fair	870	655	8,792.0	4	F-21
M-22	Hamilton Bay/Pocket	11/18/02	11/20/02	Good	770	604	6,012.0	4	F-22
M-23	Hamilton Bay/Pocket	11/25/02	11/26/02	Good	815	615	6,884.5	4	F-23
M-24	Hamilton Bay/Pocket	11/25/02	11/26/02	Good	738	568	4,627.0	4	F-24
M-25	Hamilton Bay/Pocket	11/25/02	11/26/02	Good	787	620	5,958.5	4	F-25
M-26	Hamilton Bay/Pocket	11/25/02	11/26/02	Good	755	579	5,055.0	4	F-26
M-27	Hamilton Bay/Pocket	11/25/02	11/26/02	Good	725	613	5,741.5	4	F-27
M-28	Hamilton Bay/Pocket	11/25/02	11/26/02	Good	802	628	7,006.5	4	F-28
M-29	Hamilton Bay/Pocket	11/25/02	11/26/02	Good	770	598	5,152.0	3	F-29
M-30	Hamilton Bay/Pocket	11/25/02	11/26/02	Good	763	596	5,403.5	4	F-30
M-31	Hamilton Bay/Pocket	12/5/02	12/6/02	Good	689	531	4,113.5	3	F-31
M-32	Hamilton Bay/Pocket	12/5/02	12/6/02	Good	767	579	5,640.0	4	F-32
M-33	Hamilton Bay/Pocket	12/5/02	12/6/02	Good	846	644	8,229.0	4	F-33
M-34	Hamilton Bay/Pocket	12/5/02	12/6/02	Excellent	790	608	6,197.0	3	F-34
M-35	Hamilton Bay/Pocket	12/5/02	12/6/02	Good	873	658	9,039.5	4	F-35
M-36	Hamilton Bay/Pocket	12/5/02	12/6/02	Fair	743	579	4,911.5	4	F-36
M-37	Hamilton Bay/Pocket	12/5/02	12/6/02	Excellent	721	559	4,368.0	3	F-37
M-38	Hamilton Bay/Pocket	12/5/02	12/6/02	Good	823	630	6,904.5	4	F-38
M-39	Hamilton Bay/Pocket	12/5/02	12/6/02	Excellent	720	566	4,702.0	3	F-39
M-40	Hamilton Bay/Pocket	12/5/02	12/6/02	Fair	844	652	7,486.5	4	F-40
M-41	Hamilton Bay/Pocket	12/5/02	12/6/02	Good	668	524	3,761.5	3	F-41
M-42	Hamilton Bay/Pocket	12/5/02	12/6/02	Good	835	635	7,148.5	4	F-42
M-43	Hamilton Bay/Pocket	12/5/02	12/6/02	Fair	815	631	5,937.0	4	F-43
M-44	Hamilton Bay/Pocket	12/5/02	12/6/02	Good	855	642	8,011.5	4	F-44
M-45	Hamilton Bay/Pocket	12/5/02	12/6/02	Good	743	570	5,963.5	3	F-45
M-46	Hamilton Bay/Pocket	12/5/02	12/6/02	Excellent	804	617	6,451.5	3	F-46
M-47	Hamilton Bay/Pocket	12/5/02	12/6/02	Excellent	837	636	7,716.0	4	F-47
M-48	Hamilton Bay/Pocket	12/5/02	12/6/02	Good	730	555	4,305.0	3	F-48
M-49	Hamilton Bay/Pocket	12/5/02	12/6/02	Good	762	596	5,428.0	4	F-49
M-50	Hamilton Bay/Pocket	12/5/02	12/6/02	Good	764	598	5,280.5	4	F-50
M-51	Hamilton Bay/Pocket	12/5/02	12/6/02	Fair	716	540	4,712.5	3	F-51
M-52	Hamilton Bay/Pocket	12/5/02	12/6/02	Good	820	615	7,053.0	4	F-52
M-53	Hamilton Bay/Pocket	12/5/02	12/6/02	Fair	745	587	4,854.5	4	F-53
M-54	Top of Pierce Island	12/5/02	12/6/02	Good	796	519	6,328.0	4	F-54
M-55	Top of Pierce Island	12/5/02	12/6/02	Excellent	814	586	6,210.0	3	F-55
M-56	Top of Pierce Island	12/5/02	12/6/02	Good	733	562	4,925.5	3	F-56
M-57	Top of Pierce Island	12/5/02	12/6/02	Excellent	750	579	5,144.5	3	F-57
M-58	Top of Pierce Island	12/5/02	12/6/02	Good	742	570	4,672.0	3	F-58
M-59	Top of Pierce Island	12/5/02	12/6/02	Excellent	720	550	4,686.5	3	F-59

Table 3. Continued.

Male #	Location of Capture	Date of Capture	Date of Spawning	Condition at Spawning	Fork Length (mm)	MEtH (mm)	Whole Body Weight (g)	Age	Used as Primary Male with Female #
M-60	Hamilton Bay/Pocket	12/9/02	12/10/02	Good	766	609	5,798/5	3	F-60
M-61	Hamilton Bay/Pocket	12/9/02	12/10/02	Good	692	562	3,581/5	3	F-61
M-62	Hamilton Bay/Pocket	12/9/02	12/10/02	Fair	726	557	4,721.0	3	F-62
M-63	Hamilton Bay/Pocket	12/9/02	12/10/02	Fair	725	573	4,429.0	3	F-63
M-64	Hamilton Bay/Pocket	12/9/02	12/10/02	Good	715	555	4,209.5	3	F-64
M-65	Hamilton Bay/Pocket	12/9/02	12/10/02	Good	737	583	4,602.5	3	F-65
M-66	Hamilton Bay/Pocket	12/9/02	12/10/02	Good	724	566	4,151.5	3	F-66
M-67	Hamilton Bay/Pocket	12/9/02	12/10/02	Fair	840	654	6,848.0	5	F-67
M-68	Hamilton Bay/Pocket	12/9/02	12/10/02	Fair	772	590	5,794.0	3	F-68
M-69	Hamilton Bay/Pocket	12/9/02	12/10/02	Good	824	638	7,329.0	4	F-69
M-70	Hamilton Bay/Pocket	12/9/02	12/10/02	Good	813	631	6,860.0	4	F-70
M-71	Hamilton Bay/Pocket	12/9/02	12/10/02	Excellent	765	619	5,136.0	4	F-71
M-72	Hamilton Bay/Pocket	12/9/02	12/10/02	Fair	832	647	7,029.5	4	F-72
M-73	Top of Pierce Island	12/9/02	12/10/02	Fair	800	615	6,406.0	4	F-73
M-74	Top of Pierce Island	12/9/02	12/10/02	Good	857	651	7,976.0	4	F-77
M-75	Bottom of Ives Island	12/9/02	12/10/02	Good	674	547	3,070.5	4	F-78
M-76	Hamilton Bay/Pocket	12/16/02	12/17/02	Dead	761	572	5,716.5	4	
M-77	Hamilton Bay/Pocket	12/16/02	12/17/02	Excellent	748	572	4,499.5	3	F-78
M-78	Hamilton Bay/Pocket	12/16/02	12/17/02	Good	698	559	4,209.5	3	F-79
M-79	Hamilton Bay/Pocket	12/16/02	12/17/02	Fair	854	625	7,593.5	4	F-80
M-80	Hamilton Bay/Pocket	12/16/02	12/17/02	Good	771	596	5,247.0	4	F-81
M-81	Hamilton Bay/Pocket	12/16/02	12/17/02	Poor	834	632	6,547.5	4	F-82
M-82	Hamilton Bay/Pocket	12/16/02	12/17/02	Fair	757	586	5,411.5	3	F-83
M-83	Hamilton Bay/Pocket	12/16/02	12/17/02	Fair	724	556	4,458.5	4	
M-84	Hamilton Bay/Pocket	12/16/02	12/17/02	Poor	768	586	5,104.0	4	F-84
M-85	Hamilton Bay/Pocket	12/16/02	12/17/02	Fair	760	578	5,197.0	3	
CM-1	From N. Channel	12/7/02	12/7/02	Fair	696	545	3,431.5	3	Not used, no milt
CM-2	From N. Channel	12/7/02	12/7/02	Good	715	560	3,135.0	3	CF-2 through CF-9
CM-3	From N. Channel	12/7/02	12/7/02	Good	784	600	5,527.5	3	CF-2 through CF-9
CM-4	From N. Channel	12/7/02	12/7/02	Good	755	580	4,196.5	3	CF-2 through CF-9

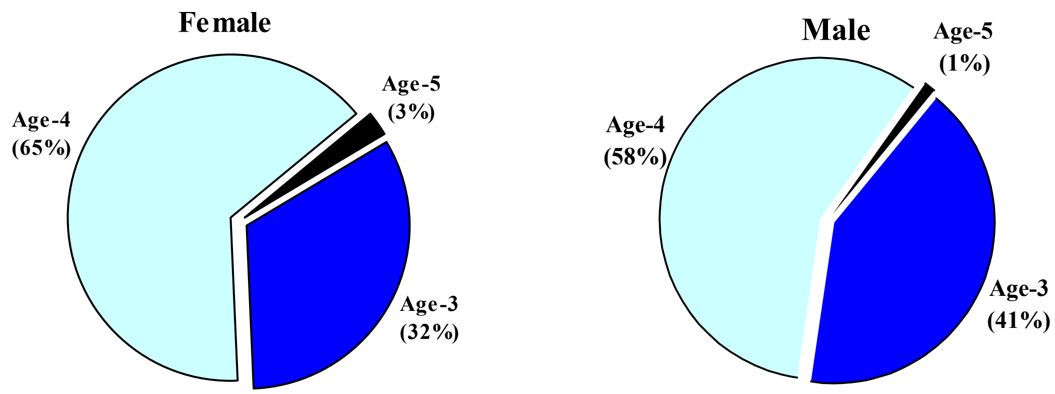

Figure 2. Age Composition of Adult Chum Spawned at Washougal Hatchery, 2002.

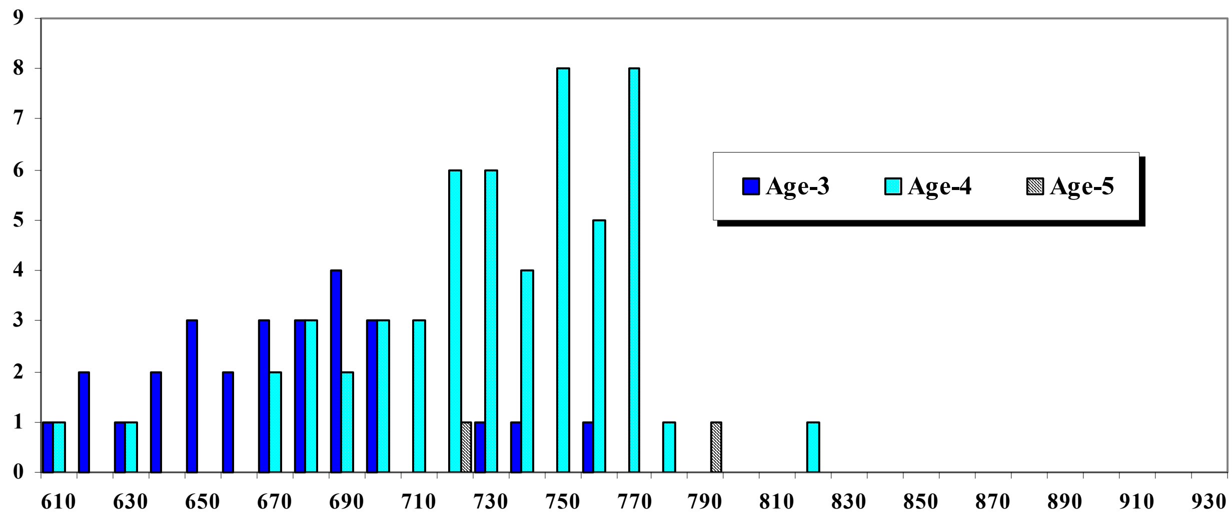

Figure 3. Fork Lengths of Female Chum Spawned at Washougal Hatchery, grouped by age and 10 mm increments, 2002.

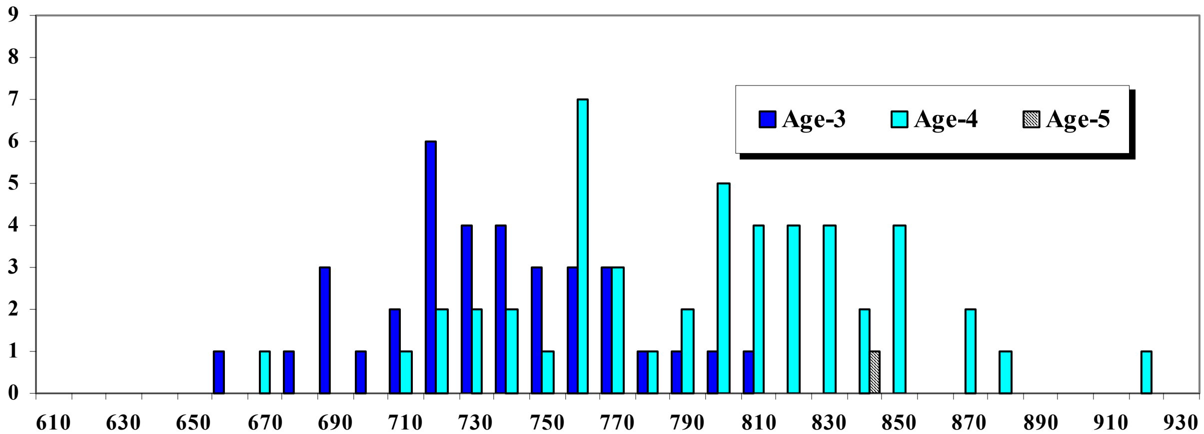

Figure 4. Fork Lengths of Male Chum Spawned at Washougal Hatchery, grouped by age and 10 mm increments, 2002.

Incubation

All green eggs were disinfected in the Heath trays with a 60-minute treatment of iodophor Betadine before being moved into the incubation stacks. Flow through the Heath stacks was set at four gallons per minute and monitored by hatchery personnel. Daily formalin treatments, 15 min per day at 470 ml per minute, were applied from day two until just before the eggs hatched (minimum of five days) to prevent fungus (*Saprolegnia sp*.) growth in the trays. At around 375, TU degrees F, the eggs were shocked by pouring them from the trays into a bucket ½ full of water and then back into their trays. After waiting 24 hours, the eggs were hand picked to remove any mortalities and unfertilized eggs. All but eight eggs from female #2 (found dead in holding tube on spawning day but spawned anyway) were non-viable. A total of 18,270 non-viable eggs were recovered after shocking (Table 4). This number decreases to 15,169 with the removal of those from female #2. From this point on in the report, unless specified, all rates and totals reported will not include data from female #2. The number of non-viable eggs per female removed after shocking ranged from 5 to 1,261 and averaged 181.

The first thermal marks were applied to the otoliths prior to hatching. Four thermal events were applied to produce the pre-hatch mark of: | | | | (wide-narrow-narrow). A post-hatching thermal mark of : | | | | | |(narrow, narrow, narrow, wide) was also applied. One day of ambient temperatures between treatments produced the narrow spacing and four days produced the wide spacing. Visualize these "|" as circles to get a good representation of the mark. Due to a power outage and a mark schedule execution error, three patterns instead of one were created in 2003 (Figures 5). These patterns are similar and should not cause recognition errors upon recovery as adults (Jeff Grimm, WDFW Otolith Lab, pers. comm.).

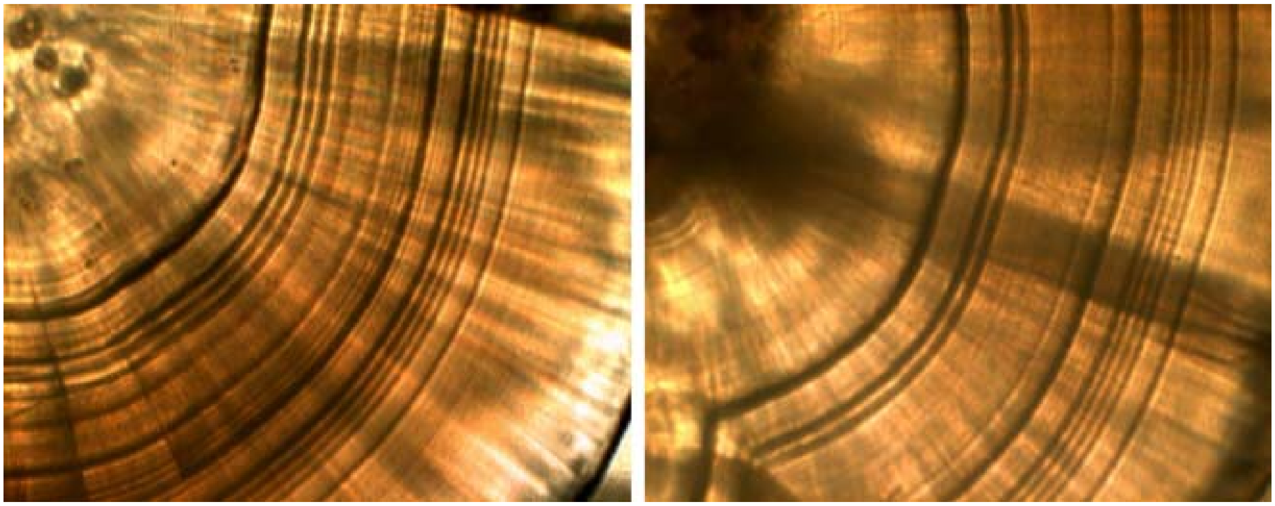

Figure 5. Photomicrographs showing the correct thermal mark (right) and one of the two errant patterns (left) created in 2003.

Fecundity estimates calculated after shocking and picking based on five samples of viable eyed eggs, including 95% C.I. and the CV of the mean, are reported in Table 4. Females brought in from the north channel (CF) were incubated as a group in two trays to conserve space. Consequently, complete individual data is not available; group data is presented when relevant. Mean fecundity estimates for females with reproductive effort values >16% only, ranged from 1,600 to 3,718, averaging 2,814. Survival rates from green to eyed egg stage ranged from 47.29% to 99.57%, averaging 92.41% (Table 4).

Table 4. Number of Non-Viable Eggs at Shocking, Mean Live Eyed Egg Estimates, 95% C.I. and C.V., Fecundity and % Survival Rates from Green to Eyed Egg Stage, 2003.

Female	Non-Viable Eggs	Eyed Egg Weight	Mean Live Eyed Egg Estimate	Total eggs	95% C.I. High	95% C.I. Low	+/-	CV	Fecundity (base on sampling*)	Survival Green to Eyed
F-1	693	796.1	2,348	3,046	2380.37	2315.63	32.37	1.11	3,046	77.08%
F-2	3,101	2.9	8	3,114	----	----	----	----	3,114	0.26%
F-3	97	1086.6	2,792	2,894	2821.95	2762.05	29.95	0.87	2,894	96.48%
F-4	61	465.2	1,581	1,647	1636.58	1525.42	55.58	2.84	1,647	95.99%
F-5	217	870.8	2,916	3,138	2970.65	2861.35	54.65	1.52	3,138	92.93%
F-6	588	609.7	2,009	2,602	2046.70	1971.30	37.70	1.52	2,602	77.21%
F-7	245	737.2	2,467	2,717	2484.70	2449.30	17.70	0.58	2,717	90.80%
F-8	60	912.5	3,105	3,170	3208.90	3001.10	103.90	2.71	3,170	97.95%
F-9	292	1086.1	3,335	3,632	3350.05	3319.95	15.05	0.36	3,632	91.82%
F-10	170	1195.7	3,665	3,840	3681.52	3648.48	16.52	0.36	3,840	95.44%
F-11	955	735.2	2,267	3,227	2300.06	2233.94	33.06	1.18	3,227	70.25%
F-12	1,261	320.7	1,136	2,402	1145.22	1126.78	9.22	0.66	2,402	47.29%
F-13	50	1187.4	3,718	3,773	3743.53	3692.47	25.53	0.56	3,773	98.54%
F-14	117	1006.6	3,173	3,295	3189.39	3156.61	16.39	0.42	3,295	96.30%
F-15	120	685.3	2,716	2,841	2740.61	2691.39	24.61	0.73	2,841	95.60%
F-16	296	798.0	2,634	2,935	2728.09	2539.91	94.09	2.89	2,935	89.74%
F-17	394	694.3	2,336	2,735	2356.30	2315.70	20.30	0.70	2,735	85.41%
F-18	106	1066.5	3,512	3,623	3574.74	3449.26	62.74	1.44	3,623	96.94%
F-19	307	1094.2	3,361	3,673	3389.34	3332.66	28.34	0.68	3,673	91.51%
F-20	725	853.4	3,049	3,774	3068.71	3029.29	19.71	0.52	3,774	80.79%
F-21	34	763.2	2,872	2,906	2892.60	2851.40	20.60	0.58	2,906	98.83%
F-22	222	949.3	3,342	3,564	3368.14	3315.86	26.14	0.63	3,564	93.77%
F-23	83	653.8	2,284	2,367	2302.40	2265.60	18.40	0.65	2,367	96.49%
F-24	5	158.2	586	591	587.92	584.08	1.92	0.26	591	99.15%
F-25	145	844.6	3,021	3,166	3043.84	2998.16	22.84	0.61	3,166	95.42%
F-26	159	936.3	3,084	3,243	3112.38	3055.62	28.38	0.74	3,243	95.10%
F-27	58	806.6	2,376	2,434	2384.50	2367.50	8.50	0.29	2,434	97.62%
F-28	289	959.4	3,155	3,444	3175.64	3134.36	20.64	0.53	3,444	91.61%
F-29	229	586.9	1,763	1,992	1777.32	1748.68	14.32	0.66	1,992	88.50%
F-30	244	756.6	2,435	2,679	2452.05	2417.95	17.05	0.57	2,679	90.89%
F-31	30	896.2	2,968	2,998	2989.73	2946.27	21.73	0.59	2,998	99.00%
F-32	50	776.8	2,742	2,792	3492.50	1991.50	750.50	0.33	2,521	98.02%
F-33	29	884.9	2,956	2,985	3034.02	2877.98	78.02	2.13	2,985	99.03%
F-34	31	512.4	2,066	2,097	2109.27	2022.73	43.27	1.69	2,097	98.52%
F-35	57	567.5	2,266	2,323	2278.88	2253.12	12.88	0.46	2,323	97.55%
F-36	191	942.1	3,336	3,527	3371.02	3300.98	35.02	0.85	3,527	94.58%
F-37	68	804.7	2,756	2,824	2775.73	2736.27	19.73	0.58	2,824	97.59%
F-38	52	696.3	2,766	2,818	2800.31	2731.69	34.31	1.00	2,818	98.15%
F-39	15	809.2	3,434	3,449	3481.27	3386.73	47.27	1.11	3,449	99.57%
F-40	28	816.7	3,060	3,088	3075.08	3044.92	15.08	0.40	3,088	99.09%
F-41	10	522.9	2,057	2,067	2064.92	2049.08	7.92	0.31	2,067	99.52%
F-42	49	996.2	2,984	3,033	3024.11	2943.89	40.11	1.09	3,033	98.38%
F-43	85	872.0	2,396	2,481	2415.01	2376.99	19.01	0.64	2,481	96.57%
F-44	61	955.9	2,830	2,891	2871.57	2788.43	41.57	1.19	2,891	97.89%
F-45	33	739.2	2,803	2,836	2814.25	2791.75	11.25	0.32	2,836	98.84%
F-46	35	717.1	2,828	2,863	2851.66	2804.34	23.66	0.68	2,863	98.78%
F-47	38	1069.3	3,463	3,501	3488.33	3437.67	25.33	0.59	3,501	98.91%
F-48	14	381.40	1,308	1,322	1323.43	1292.57	15.43	0.95	1,322	98.94%
F-49	35	714.9	2,596	2,631	2610.72	2581.28	14.72	0.46	2,631	98.67%
F-50	66	897.7	3,577	3,643	3602.42	3551.58	25.42	0.57	3,643	98.19%

Table 4. Continued

Female	Non-Viable Eggs	Eyed Egg Weight	Mean Live Eyed Egg Estimate	Total eggs	95% C.I.			CV	Fecundity (base on sampling*)	Survival Green to Eyed
					High	Low	+/-			
F-51	51	973.7	3,048	3,099	3063.09	3032.91	15.09	0.40	3,099	98.35%
F-52	351	1015.3	2,815	3,166	2845.00	2785.00	30.00	0.86	3,166	88.91%
F-53	19	540.0	1,976	1,995	1983.24	1968.76	7.24	0.30	1,995	99.05%
F-54	69	964.6	2,807	2,876	2847.41	2766.59	40.41	1.16	2,876	97.60%
F-55	348	871.9	2,805	3,153	2812.05	2797.95	7.05	0.20	3,153	88.96%
F-56	107	913.7	2,966	3,073	3146.81	2785.19	180.81	4.93	3,073	96.52%
F-57	164	749.6	3,146	3,310	3178.05	3113.95	32.05	0.82	3,310	95.05%
F-58	111	696.4	2,617	2,728	2646.69	2587.31	29.69	0.92	2,728	95.93%
F-59	54	865.9	3,019	3,073	3050.07	2987.93	31.07	0.83	3,073	98.24%
F-60	128	889.3	2,411	2,539	2428.74	2393.26	17.74	0.59	2,539	94.96%
F-61	75	696.2	2,566	2,641	2571.44	2560.56	5.44	0.17	2,641	97.16%
F-62	19	492.5	1,825	1,844	1832.75	1817.25	7.75	0.34	1,844	98.97%
F-63	23	897.1	2,849	2,872	2866.98	2831.02	17.98	0.51	2,872	99.20%
F-64	14	618.7	2,355	2,369	2371.74	2338.26	16.74	0.57	2,369	99.41%
F-65	22	955.2	2,819	2,841	2839.74	2798.26	20.74	0.59	2,841	99.23%
F-66	39	803.1	2,655	2,694	2671.82	2638.18	16.82	0.51	2,694	98.55%
F-67	98	408.1	1,393	1,491	1404.40	1381.60	11.40	0.66	1,491	93.43%
F-68	57	555.4	2,202	2,259	2214.41	2189.59	12.41	0.46	2,259	97.48%
F-69	137	595.8	2,091	2,228	2114.91	2067.09	23.91	0.92	2,228	93.85%
F-70	248	722.4	2,336	2,584	2348.77	2323.23	12.77	0.44	2,584	90.40%
F-71	188	967.4	2,813	3,001	2829.45	2796.55	16.45	0.47	3,001	93.74%
F-72	217	964.7	2,854	3,071	2869.48	2838.52	15.48	0.44	3,071	92.93%
F-73	603	752.6	2,752	3,355	2767.09	2736.91	15.09	0.44	3,355	82.03%
F-74	26	594.7	1,870	1,896	1907.50	1832.50	37.50	1.62	1,896	98.63%
F-75	29	850.4	2,625	2,654	2644.27	2605.73	19.27	0.59	2,654	98.91%
F-76	105	1038.2	3,290	3,395	3304.09	3275.91	14.09	0.35	3,395	96.91%
F-77	29	472.9	1,667	1,696	1682.27	1651.73	15.27	0.74	1,696	98.29%
F-78	288	625.9	2,281	2,569	2488.46	2073.54	207.46	7.35	2,569	88.79%
F-79	235	578.3	1,887	2,122	1897.16	1876.84	10.16	0.44	2,122	88.93%
F-80	56	796.7	2,771	2,827	2799.13	2742.87	28.13	0.82	2,827	98.02%
F-81	43	322.0	1,161	1,204	1173.95	1148.05	12.95	0.90	1,204	96.43%
F-82	105	328.3	1,368	1,473	1383.57	1352.43	15.57	0.92	1,473	92.87%
F-83					Green when spawned					
F-84	956	417.8	1,600	2,556	1625.05	1574.95	25.05	1.27	2,556	62.60%
CF-1					Only had one egg when spawned					
CF 2 -5	742	1606.3	5,628	6,370	5792.31	5463.69	164.31	2.36	----	88.35%
CF6 - 9	214	2629.6	8,285	8,499	8477.76	8092.24	192.76	1.88	----	97.48%

* Fecundity calculated using mean number of live eyed eggs + dead eggs removed + five eggs removed at spawning for calculating water hardened green egg weight.

The eggs began to hatch after they had accumulated approximately 600 TU ^{0}F. A total of 2,699 dead alevins, 818 non-viable eggs and 438 monstrosities were removed from the trays prior to ponding. The resultant loss totaled 3,955 (1.75%) from picked eyed eggs to ponding. Loss, by female, from the green egg stage to ponding is detailed in Table 5.

K_D values of fry from each tray at ponding are presented in Table 6. Individual fork lengths and weights were taken on five fry from each tray just prior to ponding. Fork lengths ranged from 32 mm to 42 mm, and averaged 38.0 mm. Individual weights ranged from 0.24 g to 0.53 g, averaging 0.36 g.

Table 5. Breakdown of Loss by Female from the Green Egg Stage to Ponding, 2003.

Female #	Loss at shocking	# Non-Viable Eggs at Hatching	# Alevin Mortalities	Monstrosities Removed	Total	% Loss
F-1	693	6	29	6	734	24.10%
F-2	3,101	1	0	0	3,102	99.61%
F-3	97	3	2	0	102	3.52%
F-4	61	4	184	0	249	15.12%
F-5	217	0	144	3	364	11.60%
F-6	588	2	52	7	649	24.94%
F-7	245	10	5	3	263	9.68%
F-8	60	6	4	4	74	2.33%
F-9	292	28	9	15	344	9.47%
F-10	170	31	40	15	256	6.67%
F-11	955	11	1	0	967	29.97%
F-12	1,261	5	0	2	1,268	52.79%
F-13	50	6	176	4	236	6.25%
F-14	117	5	1	0	123	3.73%
F-15	120	4	0	3	127	4.47%
F-16	296	40	26	3	365	12.44%
F-17	394	6	2	0	402	14.70%
F-18	106	3	45	4	158	4.36%
F-19	307	0	4	6	317	8.63%
F-20	725	15	7	36	783	20.75%
F-21	34	6	2	0	42	1.45%
F-22	222	0	55	6	283	7.94%
F-23	83	56	1	4	144	6.08%
F-24	5	0	0	2	7	1.18%
F-25	145	4	1	2	152	4.80%
F-26	159	13	4	2	178	5.49%
F-27	58	2	2	0	62	2.55%
F-28	289	2	1	1	293	8.51%
F-29	229	1	2	2	234	11.75%
F-30	244	3	4	2	253	9.44%
F-31	30	4	10	3	47	1.57%
F-32	50	0	0	5	55	2.18%
F-33	29	6	4	7	46	1.54%
F-34	31	8	2	3	44	2.10%
F-35	57	1	1	1	60	2.58%
F-36	191	10	33	13	247	7.00%
F-37	68	2	0	0	70	2.48%
F-38	52	0	0	3	55	1.95%
F-39	15	8	5	1	29	0.84%
F-40	28	3	1	2	34	1.10%
F-41	10	56	8	12	86	4.16%
F-42	49	5	1	5	60	1.98%
F-43	85	39	12	18	154	6.21%
F-44	61	0	12	6	79	2.73%
F-45	33	27	0	8	68	2.40%
F-46	35	7	49	7	98	3.42%
F-47	38	0	5	3	46	1.31%

Table 5. Continued

Female #	Loss at shocking	# Non-Viable Eggs at Hatching	# Alevin Mortalities	Monstrosities Removed	Total	% Loss
F-48	14	0	2	4	20	1.51%
F-49	35	3	2	8	48	1.82%
F-50	66	5	0	5	76	2.09%
F-51	51	15	48	1	115	3.71%
F-52	351	19	2	12	384	12.13%
F-53	19	0	14	4	37	1.85%
F-54	69	0	782	6	857	29.80%
F-55	348	0	227	3	578	18.33%
F-56	107	4	1	3	115	3.74%
F-57	164	1	2	1	168	5.08%
F-58	111	2	5	3	121	4.44%
F-59	54	4	1	3	62	2.02%
F-60	128	1	2	6	137	5.40%
F-61	75	3	3	23	104	3.94%
F-62	19	0	2	1	22	1.19%
F-63	23	0	1	0	24	0.84%
F-64	14	0	106	3	123	5.19%
F-65	22	0	0	3	25	0.88%
F-66	39	0	6	3	48	1.78%
F-67	98	0	0	0	98	6.57%
F-68	57	156	11	10	234	10.36%
F-69	137	11	9	5	162	7.27%
F-70	248	6	7	3	264	10.22%
F-71	188	2	23	3	216	7.20%
F-72	217	1	13	1	232	7.55%
F-73	603	2	3	0	608	18.12%
F-74	26	3	12	4	45	2.37%
F-75	29	0	183	6	218	8.21%
F-76	105	5	14	4	128	3.77%
F-77	29	0	0	3	32	1.89%
F-78	288	2	2	2	294	11.44%
F-79	235	3	1	5	244	11.50%
F-80	56	103	2	2	163	5.77%
F-81	43	0	2	2	47	3.90%
F-82	105	1	6	4	116	7.88%
F-84	956	10	3	4	973	38.07%
CF 2 - 5	742	3	19	17	781	12%
CF 6 - 9	214	4	237	42	497	6%

Table 6. Average Weights, Fork Lengths, Date Ponded and KD Values at Ponding by Female, 2003.

Female #	# Fry Sampled	Average Weight (g)	Average Fork Length (mm)	Date Ponded	K_D Value
F-1	5	0.37	37.80	3/17/03	1.89
F-2	5	0.43	39.40	3/17/03	1.92
F-3	5	0.51	41.80	3/19/03	1.92
F-4	5	0.37	39.20	3/19/03	1.84
F-5	5	0.35	37.80	3/19/03	1.87
F-6	5	0.31	36.20	3/19/03	1.87
F-7	5	0.33	37.20	3/19/03	1.85
F-8	5	0.36	38.00	3/26/03	1.87
F-9	5	0.40	38.40	3/26/03	1.93
F-10	5	0.40	38.80	3/26/03	1.90
F-11	5	0.41	39.60	3/26/03	1.87
F-12	5	0.37	39.20	3/27/03	1.83
F-13	5	0.35	37.60	3/27/03	1.88
F-14	5	0.38	38.00	3/27/03	1.91
F-15	5	0.30	36.60	3/27/03	1.83
F-16	5	0.38	38.00	3/27/03	1.91
F-17	5	0.35	38.40	3/27/03	1.83
F-18	5	0.33	38.00	3/27/03	1.83
F-19	5	0.42	38.20	3/27/03	1.97
F-20	5	0.33	37.00	3/27/03	1.86
F-21	5	0.31	36.80	3/27/03	1.84
F-22	5	0.31	36.40	3/27/03	1.85
F-23	5	0.34	36.80	4/06/03	1.89
F-24	5	0.37	38.20	4/06/03	1.87
F-25	5	0.34	38.80	4/06/03	1.80
F-26	5	0.36	38.20	4/06/03	1.87
F-27	5	0.43	41.60	4/06/03	1.82
F-28	5	0.36	38.80	4/06/03	1.84
F-29	5	0.41	40.00	4/06/03	1.85
F-30	5	0.37	39.60	4/06/03	1.81
F-31	5	0.34	35.40	4/09/03	1.97
F-32	5	0.39	39.20	4/09/03	1.87
F-33	5	0.34	37.80	4/09/03	1.85
F-34	5	0.28	34.60	4/09/03	1.90
F-35	5	0.29	36.20	4/09/03	1.82
F-36	5	0.34	36.80	4/09/03	1.89
F-37	5	0.40	39.00	4/09/03	1.90
F-38	5	0.33	38.20	4/09/03	1.81
F-39	5	0.31	38.00	4/09/03	1.78
F-40	5	0.33	37.20	4/09/03	1.85
F-41	5	0.38	38.20	4/09/03	1.89
F-42	5	0.38	38.20	4/09/03	1.89
F-43	5	0.40	36.60	4/09/03	2.02
F-44	5	0.37	38.40	4/09/03	1.88
F-45	5	0.30	36.20	4/09/03	1.85
F-46	5	0.28	34.20	4/09/03	1.92
F-47	5	0.38	38.00	4/09/03	1.90
F-48	5	0.38	38.60	4/09/03	1.87
F-49	5	0.30	35.60	4/09/03	1.88
F-50	5	0.31	36.60	4/10/03	1.85
F-51	5	0.40	39.20	4/10/03	1.88
F-52	5	0.46	41.20	4/10/03	1.88

Table 6. Continued

Female #	# Fry Sampled	Average Weight (g)	Average Fork Length (mm)	Date Ponded	K_D Value
F-53	5	0.32	37.4	4/10/03	1.83
F-54	5	0.44	39.6	4/10/03	1.92
F-55	5	0.40	38.8	4/10/03	1.90
F-56	5	0.38	39.4	4/09/03	1.85
F-57	5	0.26	34.8	4/09/03	1.83
F-58	5	0.30	36.2	4/09/03	1.85
F-59	5	0.33	37.6	4/10/03	1.83
F-60	5	0.45	40.4	4/16/03	1.90
F-61	5	0.33	37.8	4/16/03	1.83
F-62	5	0.34	38.4	4/17/03	1.82
F-63	5	0.38	39.8	4/17/03	1.83
F-64	5	0.35	36.8	4/17/03	1.91
F-65	5	0.41	38.8	4/17/03	1.91
F-66	5	0.40	40.0	4/17/03	1.84
F-67	5	0.39	39.8	4/17/03	1.84
F-68	5	0.33	37.6	4/17/03	1.83
F-69	5	0.33	37.6	4/16/03	1.83
F-70	5	0.40	38.8	4/16/03	1.90
F-71	5	0.43	39.4	4/16/03	1.92
F-72	5	0.40	38.6	4/16/03	1.91
F-73	5	0.32	37.2	4/17/03	1.84
F-74	5	0.35	36.6	4/17/03	1.92
F-75	5	0.37	37.8	4/17/03	1.90
F-76	5	0.37	37.2	4/17/03	1.93
F-77	5	0.38	38.4	4/17/03	1.88
F-78	5	0.32	37.0	4/17/03	1.84
F-79	5	0.41	39.6	4/17/03	1.88
F-80	5	0.34	37.2	4/17/03	1.88
F-81	5	0.33	36.8	4/17/03	1.87
F-82	5	0.30	36.4	4/17/03	1.84
F-84	5	0.29	36.2	4/17/03	1.82
CF 2 - 5	5	0.37	38.0	4/10/03	1.89
CF 6 - 9	5	0.36	35.4	4/10/03	2.00

Rearing

A total of 221,565 fry were ponded in eight rearing troughs. Trough #1 received 26,178 fry (females 1-10 and 16). Trough #2 received 31,067 fry (females 11-15 and 17-22). Trough #3 received 30,251 fry (females 23-31). Trough #4 received 32,273 fry (females 32-43). Trough #5 received 28,995 fry (females 44-54). Trough #6 received 19,177 fry (females 55,59 and CF 2-9). Trough #7 received 33,492 fry (females 60-73). Trough #8 received 20,132 fry (females 74-82 and 84). Flow rates were initially set at 25 gpm and adjusted by hatchery personnel as the fry grew to maintain the flow index within an acceptable range.

Three weight samples of 25 fry for each trough were collected each week to calculate daily feed amounts and to gauge when they would be ready for release. The fry were fed at a rate of 3% body weight per day. Feeding occurred at least eight times per day, approximately 1/8th of the daily ration every hour. A total of 38.6 pounds of Moore Clark brand #0 crumb and 25.7 pounds of Moore Clark brand #1 starter feed was used over the 65-day rearing period. Fry sampling results are provided in Table 7.

DO levels in the troughs ranged from 11.1 to 13.0, averaging 12.0, during the rearing period. Water temperatures over the rearing period averaged 50 ^{0}F and 43 ^{0}F, afternoon and morning respectively. Mortalities were removed and enumerated daily. A total of 4,129 mortalities were removed from the eight troughs between ponding and release, resulting in a survival rate of 98.1%.

Release

A total of 217,436 fry were released at night from the Skamania Landing's boat ramp, located on the Columbia River immediately downstream from the mouth of Duncan Creek. The overall survival rate from green egg stage to release was 90.3%, dropping to 89.2% with the addition of female #2. Fry were liberated on three different occasions, troughs #1 and #2 were released the night of May 8, troughs #3 through #5 and #7 were released the night of May 19, and troughs #6 and #8 the night of May 21. Results of the sampling done the day of release are reported in Table 8. The fry were dip netted from the troughs and placed into a 400-gallon tanker truck for transport to the release site. The truck was backed down the ramp and a flex hose attached to the tank to get the fry into the water. The fish were monitored for 15-20 minutes for any immediate mortality and to ensure that they moved off into deeper water. Less than 30 direct mortalities for the three combined releases were observed at release.

Table 7. Results of Fry Sampling, 2003.

Sample Date	Trough #1 Average Size (g)	Trough #1 # Fish/lb	Trough #2 Average Size (g)	Trough #2 # Fish/lb	Trough #3 Average Size (g)	Trough #3 # Fish/lb	Trough #4 Average Size (g)	Trough #4 # Fish/lb	Trough #5 Average Size (g)	Trough #5 # Fish/lb	Trough #6 Average Size (g)	Trough #6 # Fish/lb	Trough #7 Average Size (g)	Trough #7 # Fish/lb	Trough #8 Average Size (g)	Trough #8 # Fish/lb
17-Mar	0.383	1,183														
19-Mar	0.388	1,170														
26-Mar	0.387	1,172	0.352	1,289												
6-Apr					0.355	1,278										
7-Apr	0.544	834	0.466	973	0.360	1,261										
9-Apr							0.349	1,302	0.358	1,266						
10-Apr											0.363	1,250				
14-Apr	0.663	684	0.565	803	0.393	1,156	0.356	1,275	0.363	1,250	0.336	1,352				
16-Apr													0.376	1,208		
20-Apr	0.865	525	0.785	578	0.549	826	0.519	874	0.493	921	0.461	984	0.415	1,092		
21-Apr															0.345	1,316
28-Apr	1.080	420	1.043	435	0.671	676	0.684	663	0.690	657	0.636	714	0.584	777	0.410	1,106
5-May	1.428	318	1.260	360	0.843	538	0.825	550	0.849	534	0.704	644	0.803	565	0.591	768
8-May	1.609	282	1.517	299	*Released troughs 1 &2*											
11-May					1.037	438	0.971	467	1.078	421	0.802	566	0.916	495	0.695	652
18-May					1.381	328	1.327	342	1.337	339	1.192	380	1.228	369	1.096	414
19-May		*Released troughs 3-5 & 7*			1.332	341	1.244	365	1.381	329			1.250	363		
21-May								*Released troughs 6 & 8*			1.168	388			0.955	475

Table 8. Average Size (g), Fork Lengths (mm) and Kd Values by Trough on Release Day, 2003.

	Trough #1	Trough #2	Trough #3	Trough #4	Trough #5	Trough #6	Trough #7	Trough #8
# Released	25,887	30,583	29,141	31,830	28,688	18,135	33,351	19,821
Release Date	5/8/2003	5/8/2003	5/19/2003	5/19/2003	5/19/2003	5/21/2003	5/19/2003	5/21/2003
Average FL (STD)	58.92 (5.07)	58.02 (3.90)	56.22 (4.15)	54.72 (4.19)	56.38 (2.75)	53.46 (3.76)	54.76 (2.92)	50.82 (3.27)
Average Wt. (STD)	1.609 (0.39)	1.5174 (0.29)	1.3318 (0.28)	1.2442 (0.26)	1.3806 (0.20)	1.1678 (0.23)	1.2498 (0.20)	0.9554 (0.17)
Average Kd STD)	1.97 (0.04)	1.97 (0.07)	1.95 (0.08)	1.96 (0.04)	1.97 (0.05)	1.96 (0.06)	1.96 (0.05)	1.93 (0.04)

Discussion

In 2002, 171 adult chum were collected for artificial propagation at Washougal Hatchery, compared to only 51 adults collected in 2001. In addition, 13 adults were removed from the north channel of Duncan Creek due to critically low water levels on December 7, 2002. These fish were also spawned at the Washougal Hatchery. A total of 92 females were spawned, yielding an estimated 244,156 green eggs. The 2002-03 survival rate from green to eyed egg stage was 92.5%, compared to 82.9% in 2001-02. The low rate in 2001-02 was a result of the total loss of one female's egg production and an overestimation in the calculation for the number of green eggs per female at spawning. When formulating the 2001-02 predictive regression formulas the fecundity estimate at the eyed egg stage was on average 87% of the fecundity estimate recorded at the green egg stage (live and dead eggs combined). This difference should not be more than two or three percent. This error was likely due to incomplete draining of ovarian fluid before weighing the green egg mass. Overall, this year's fecundity estimates at green and eyed egg stage differed by less than one percent. A total of 3,955 mortalities were recovered between the eyed egg stage and ponding, resulting in a mortality rate of 1.75%. In 2001-02, a total of 6,664 mortalities were recovered between the eyed egg stage and ponding, mostly due to an outbreak of *Saprolegnia sp.*, resulting in a mortality rate of 12.6%. The hatchery protocols that changed in 2002-03 and likely contributed to this decrease in mortality were: eggs were shocked more aggressively, and vexar was not added to the trays until after picking. A total of 4,129 mortalities were recovered between ponding and release, yielding a survival rate of 98.1% from ponding to release. This is the same as the 2001-02 rate, indicating that the higher densities in the rearing troughs during the 2002-03 season had little or no effect on the mortality rate. Three nighttime releases totaling 217,436 chum fry were made near the mouth of Duncan Creek in May of 2003. Resulting in an overall estimated survival rate from green egg to release of 90.3%. This compares to a rate of 78.2% achieved in 2001-02.

Washougal Hatchery operations for chum salmon were very successful in 2002-03. In 2001, all of the females were spawned at the hatchery before a single adult was placed into the renovated Duncan Creek channels. Once fish began being placed in the channels, no additional adults were brought to the hatchery. In 2001, the age composition of the fish placed into the channels verses those spawned at the hatchery were drastically different. In 2002 a plan was developed to collect brood stock for the channels and hatchery over the whole spawning season. While the ages of the fish used in the hatchery and channel were not exactly the same they were more similar in 2002. Sampling and data collection was more precise and complete in 2002-03 and the accuracy of the predictive fecundity formulas increased. Similar to 2002, the fry from the hatchery were not ready for release until May. Ideally these fry would be ready for release at the same time as fry naturally produced in the channels are outmigrating. If the intent is to continue using Washougal Hatchery facilities to rear the artificially-spawned juveniles, a heated water system may be necessary to duplicate temperatures that naturally produced fry experience in the channels.

The number of adults spawned in 2002 was a response to concerns that low winter/spring flows in the Columbia River around the Hamilton/Ives/Pierce islands could de-water chum redds or strand fry prior to emergence. This response followed the plans developed for a predicted low flow year that are presented in the chum salmon HGMP for the Washougal Hatchery. Soon after natural spawning was complete, however, it became evident that flow levels would be adequate to protect the chum redds in located below the Bonneville Dam. Therefore, a full salvage plan was not implemented, fry were not differentially marked and all fry were released near Duncan Creek. However, responding to the low flow forecast did expose potential problems if a full salvage plan were implemented. Specifically, incubation and rearing space at Washougal Hatchery is limited. Space for only 56 females (four stacks of Heath trays) to be individually incubated was allocated in 2002. The Duncan M&E requires up to 50 females to be spawned and individually incubated for formulation of the fecundity predictive regression formulas. Stopping individual incubation at 50 females leaves six trays for bulk incubation, room for another 30 females. A full salvage plan responding to low flows in all areas used by LG chum salmon requires incubation space for a minimum of 150 females. Using a combination of individual and bulk incubation, 150 females would require a minimum of eight stacks. Only five stacks would be needed for incubation, but thermal marking requires each group to be in separate stacks for differential marking. Tray dividers, possibly allowing up to four females to be individually incubated in a single Heath tray, will be evaluated during the 2003-04 season. If the tray dividers prove to have no impact on incubation survival rates, the number of stacks needed for even the most extreme salvage plan could be reduced to five. Limited rearing space at Washougal Hatchery is another concern. Currently, only one raceway is designated for rearing chum. This raceway is not used in the traditional method. The inflow designated has been plumbed into a manifold to provide flow to eight small fiberglass troughs, each having space to rear up to approximately 31,000 fry to release size (troughs are not all uniform in size). These smaller troughs are needed to maximize the survival and growth of fry after ponding. Under the most extreme salvage plan, a minimum of 150 females need to be spawned and assuming a 90-95% survival rate from green egg to ponding, a minimum of 14 troughs of the size currently used would be needed if all the fry were to be reared to release size at the Washougal Hatchery. Because a single raceway inflow can only provide adequate flow for eight troughs, the number of fry that can be reared without needing another complete raceway would be approximately 260,000 (85-90 females depending on survival rate to ponding). While it is possible to increase the number of incubation stacks used without severely impacting production of other salmon species at Washougal Hatchery, using two raceways would severely impact other rearing programs at the hatchery.

Part II: Monitoring of the Physical Attributes of the Spawning Channels

Introduction

Historically, Duncan Creek was an important spawning area for chum salmon. After the construction of a pond in the lower portion of Duncan Creek in 1961, chum salmon abundance in the creek declined. In 1999 chum salmon were listed under the ESA and recovery efforts increased. Spawning channels have been used successfully to establish and re-establish chum salmon populations (Bonnell 1984; Cowan 1984). After preliminary investigation by WDFW, PSMFC, and KPFF engineering, it was determined that a spawning channel in Duncan Creek could be successful for if passage conditions at the pond outlet could be modified and pond levels managed to assist in migration. The original chum salmon spawning area in Duncan Springs was rehabilitated in October, 2000, and a chum salmon spawning channel was constructed at this site in October, 2002, by KPFF engineering. See Appendix A of Hillson (2002) for details of the channel's engineering and construction.

Continued monitoring of the physical attributes of the spawning channels is an important component of the re-introduction program. Monitoring the environmental conditions will identify factors responsible for survival/mortality rates. Salmonid research demonstrates that extremely high mortality rates, up to 99%, can occur between fertilization and emergence (Wickett 1952; Hunter 1948; Neave and Foster

1955). Several studies have attempted to identify mortality causes during the period of incubation (see Wickett 1954; Wickett 1958; Alderdice *et al*. 1958; McNeil 1962; Cooper 1965; McNeil 1966, 1983; Loptspeich and Everest 1981; Alexander and Hansen 1986; Kondolf *et al*. 1991; Marten 1992; Geist and Dauble 1998; Argent and Flebbe 1999; Baxter and McPhail 1999). Temperatures of less than 36 ^oF during the spawning period can delay spawning and increase egg retention rates (Schroder 1973; Koski 1975). Relatively low or high temperatures prior to blastopore closure have also been shown to cause high mortality rates in salmonid embryos (Brannon 1987; Tang et al. 1987; McNeil and Bailey 1975). Several researchers have linked embryonic salmonid survival to the composition of spawning gravels, specifically the proportion of materials ≤ 3.3mm, fines and sand. Materials of this size can reduce permeability of the gravel, thus reducing oxygen exchange and intra-gravel flows (McNeil and Ahnell 1964; Koski 1966, 1975; Tagart 1976, 1984; Witzel and MacCrimmon 1983). Lotspeich and Everest (1981) proposed that the geometric mean of the spawning substrate particle (D_g) be divided by its associated standard deviation (S_g) to produce the "Fredle Index" (f_i). Chapman (1988) plotted Fredle Index values against egg-to-fry survival rates from four independent studies and found that survival rates increased as the Fredle value rose from one to four. The gravel "recipe" placed in the Duncan Creek spawning channels was expected to yield a fredle index value of 5.2 (Table 9).

Table 9. Composition of Gravel to be Placed in the Duncan Creek Spawning Channel.

Diameter of Gravel	Expected Volume (%)
4 –6 inch rock	2
2.5 – 4 inch rock	13
1 - 2.5 inch rock	35
0.75 –1 inch rock	35
0.375 – 0.75 inch rock	10
No. 4 – 0.375 inch rock	5
No. 10 – No. 4 material	0

Environmental factors often cited as having the greatest influence for incubation survival include: redd superimposition, scouring and gravel fill as a result of dynamic river flows, high or low water temperatures during critical incubation times, sedimentation or high levels of sand and silt in the spawning gravels, low seepage velocity and/or low dissolved oxygen levels in the interstitial spaces, dewatering of eggs or alevins, and the presence of intra-gravel predators. Of the factors identified above, gravel composition, water temperature, low seepage velocity (vertical hydraulic gradients) and/or low DO levels in the interstitial spaces are of primary concern in the Duncan Creek channels. Monitoring these environmental conditions will provide the information needed to characterize the conditions in the channels between fertilization and emergence. The other environmental factors identified, while important, should not be of great concern since this spawning area is in a spring channel and protected from extreme environmental variation. Factors such as redd superimposition and egg retention due to overcrowding can be controlled by maintaining densities of females at levels that ensure each female has at least three square meters of spawning area and placing the fish into the channels over a two or three day period (Schroder 1973), but this should not be a factor until adult abundance in the channel approaches capacity.

Annual sampling of the gravel in the channels will document changes in gravel composition, with emphasis on material less than 3.3 mm in diameter, such as sands and fines. If annual gravel monitoring documents the Fredle Index decreasing over time, or percentage of fines less than 0.85mm increasing, this could trigger gravel-cleaning efforts. Piezometers will be used to monitor and document water temperatures, seepage velocities (vertical hydraulic gradients) and DO levels present in the hyporheic zone.

Gravel sampling was scheduled to be done prior to introducing fish into the channels during fall of 2001. However, due to limited resources it was not done until late in the summer of 2002, after the first year of use. Lake levels remained high and gravel sampling was limited to the upper two-thirds of one channel. In 2003, gravel sampling was scheduled for the last week of May after fry trapping had ceased. However, flows on the Columbia River increased and flooded the channels prior to sampling. By agreement, the gates controlling lake formation were closed on June 1, preventing any gravel sampling in the spring. Gravel sampling will occur as soon as lake levels allow in the fall of 2003. Flooding the channels is intentionally done to limit re-colonization of non-indigenous plant species, specifically reed canary grass (*Phalaris arundinacea)*.

Methods

The protocol for selecting and analyzing gravel samples outlined in the Duncan M&E will be followed (Schroder 2000). A total of twenty gravel core samples were scheduled to be collected from the area above the weirs in each channel, 60 samples total. Two channels located above the south weir were sampled independently (Figure 6). The south channel would be sampled to its confluence with the middle channel, and the middle channel would be sampled to the weir. Sampling locations were determined by measuring center channel length to the weirs, south channel measured to confluence with middle. The channels will then divided into four equal sections, and these sections divided into ten equal plots. A random number generator will be used to select five plots in each section (four sections, with five sampled plots each, resulting in 20 samples per channel). Section and plot boundaries are marked with survey flags inserted into the gravel. All samples will be taken in the center of the channel on the plots downstream boundary.

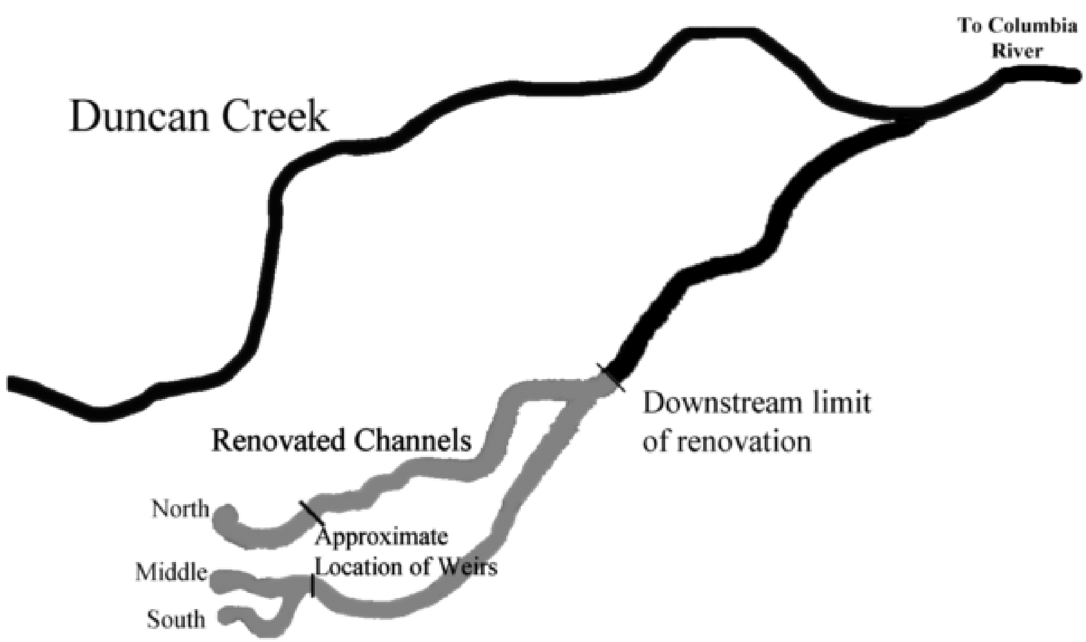

Figure 6. Diagram of Duncan Creek and the New Renovated Channels.

A McNeil Sampler (McNeil and Ahnell 1964) will be used to collect standardized core samples. The sampler is inserted into the substrate approximately six inches. All material inside the sampling cylinder, six inches deep by four inches in diameter, is removed by hand and placed in the larger cylinder. Fines suspended in the water column by excavation activities are collected by slowly inserting a plunger/gasket to the bottom of the sampling cylinder. This plunger has a one-way-flapper valve to allow it to be inserted without driving the water and suspended materials out into the surrounding gravel. Once the plunger is at the bottom of the sampling cylinder, it is pulled up approximately ½" to form a seal with the gasket. Then the sampler, gravel and water retained inside, is lifted from the streambed and placed over a five-gallon plastic pail. The contents of the sampler are then released into the pail by allowing the plunger to fall. Gravel remaining in the large cylinder of the sampler is poured into the pail; additional water is used if needed to rinse all materials from the sampler. When the water depth in the channel is approximately ≥ 12", additional pails are needed to hold the complete sample. Figure 7 is a composite of four pictures taken during the summer of 2002 gravel sampling. Arranged clockwise from upper left, these are: 1) removing the gravel from inside the samplers core, 2) the sampler being placed on a collection bucket, 3) looking down into the sampler (with gravel and water inside) after the plunger has been released and, 4) pouring the remainder of the sample into the collection bucket.

Figure 7. Taking a Gravel Sample With a McNeil Sampler.

In 2002 samples were dried and processed through a series of nine Tyler sieves (76.1 mm, 50.0 mm, 25.0 mm, 12.5 mm, 9.51 mm, 6.35 mm, 4.76 mm, 2.36 mm and 1.70 mm) using a Tyler sieve shaker. The weight of materials retained on each sieve and the solid bottom pan were recorded. These weights were then converted to weight fractions (%) of the sample. In 2003 samples will be processed using the volumetric method as outlined in Schuett-Hames (1999). This method is relatively quicker, no drying of the samples is needed, and yields % volume of the total sample by size class in place of % sample weight. Gravel samples will be processed through nine Tyler sieves (75.0 mm, 50.0 mm, 25.0 mm, 12.5 mm, 6.3 mm, 4.75 mm, 2.00 mm, 1.7 mm and 850 µm). Values for D_g will be calculated for each sample from the sieve data by the method of moments, according to Shirazi et al. (1981):

$$D_g = d_1^{w1} \text{ x } d_2^{w2} \text{ x } \ldots \text{ x } d_n^{wn} \qquad (1)$$

Where $d_1 \ldots d_n$ = sieve size (mm) $1 \ldots n$; and $w_1 \ldots w_n$ = percent of sample volume retained on sieve $1 \ldots n$.

Values for S_g will be calculated using the “non-biased” or “n-1” method:

$$S_g = \sqrt{(n\sum x^2 - (\sum x^2))/n(n-1)} \qquad (2)$$

A -Fredle Index is then calculated based on these samples (Sowden and Power 1985):

$$f_i = D_g / S_g \qquad (3)$$

Rood (1998) provided a formula for calculating the precision (I) at which a particular fraction of the gravel was collected:

$$I = DF/F^* \qquad (4)$$

Where, F* is the mean percentage of a particular fraction and DF is the confidence interval around that mean percentage. Applying this formula to the data collected allowed precision estimates to be calculated for particular gravel fractions and determine if 20 samples per channel was adequate to provide the desired precision rate ($I \leq 10\%$).

Water temperatures were continuously monitored using 18 Onset® Optic StowAway® data loggers, set to record the temperature every two hours. The data loggers were placed into a section of two-inch diameter perforated PVC pipe six to eight inches long. Six of these units were attached to sections of ¾” rebar driven into the gravel substrate to anchor the data logger. Two were placed into each channel, one at the top and the other just above the weir or confluence, at mid-water depth. The remaining 12 were attached to lengths of eighth inch stainless cable and buried 12” in the channel substrate, four per channel evenly spaced down the channel’s length to the weir or confluence. The other end of the cable was attached to ¾” rebar driven into the banks as anchors. Data from these recorders were recovered at the end of the season after fry trapping ended.

Mini-piezometers were placed at the top and then every 50’ down the length of each channel to the weir or confluence to monitor DO levels, vertical hydraulic gradients (VHG) and water temperatures in the hyporheic zone. The mini-piezometers were placed at approximately mid-channel and driven 12” into the substrate so that intra-gravel water could be sampled at the same depth as eggs were expected to be deposited. Once adults are placed into the channels, measurements of DO and temperature (three readings at each mini-piezometer to calculate a mean value) would be recorded every two weeks until fry emigration was complete. Mid-water temperature and DO values were also recorded outside the first and last piezometer in each channel when values inside the piezometers were recorded. VHG values would be determined three times over the course of the season; once at the end of spawning, again at the end of December when typical winter flows are occurring and finally at the end of the fry emigration in the spring. VHG values are determined using the following formula:

$$\text{VHG} = \Delta h / \text{L} \qquad (5)$$

Where Δh is the measured difference in water elevation between the inside of the piezometer and the outside stream water surface. Calculated as h_s-h_1, where h_s is the distance from the top of the piezometer to the stream surface and h_1 is the distance from the top of the piezometer to the water surface inside the piezometer. In the formula L equals the distance below the streambed to the top of the first row of piezometer holes (Barnard and McBain 1994; Dahm and Valett 1998). Positive VHG values indicate upwelling occurrence and negative values indicate areas of down-welling (Freeze and Cherry 1979).

Water velocity and depth measurements were also recorded. Water velocity was measured using a digital current meter just prior to introducing adults, immediately after all adults in a channel have perished and then monthly until fry emigration had ceased. Velocities were measured just upstream of the two weirs and the south channel's confluence, three readings were taken at each location to calculate a mean. Water depth was measured by placing staff gauges on the upstream side of each weir. Staff gauge levels were recorded every other day during the fall and early winter, then daily once fry trapping began through the end of the season. Changes in staff gauge readings due to activities such as installing and removing grates in the weirs and installing fry traps were recorded so readings could be normalized over the season.

Results

No gravel sampling occurred during this report period. Gravel sampling was scheduled for the last week of May, 2003, right after fry trapping had ceased. However, flows on the Columbia River were increased in an effort to decrease travel time of yearling salmonids at this time. Similar to last year during fry trapping activities, this increase in flow resulted in the lake filling to a level that floods the channels. Under an agreement with the Skamania Land Owners Association, the gates controlling the lake level were closed on June 1 to fill the lake for summer recreational use. In 2003, the gates were closed on a full lake with no opportunity for gravel sampling.

Sub-surface temperature data loggers were in place on November 4, and the mid-water loggers were placed on November 5, 2002. All temperature loggers were recovered on May 22, 2003. However, when the loggers were downloaded they all contained zero to three data points. It was discovered that a mistake made when double-checking the temperature recording parameters, logger serial number, file name and placement information before the loggers were installed had de-activated the loggers. The only way to check all this information was to go back into the launching menu of the Onset® software. This was done and then the cancel function was used to back out of the menu so another logger could be checked. It was discovered that "canceling out" and not re-launching, had turned the loggers off. Sub-surface and mid-water temperature values are available from the bi-monthly sampling at the mini-piezometers (Table 10). Piezometers were assigned numbers, increasing sequentially, from the top of the channel to confluence for the south channel and to the weirs for the other two channels. Values reported as top and bottom in Table 10 are those recorded outside the first and last piezometer in each channel. Because the majority of the adults placed in the north channel spawned in the area around the #2 mini-piezometer and it's distance from shore, this piezometer was not sampled for the majority of the season. Mean DO values from bi-monthly sampling at the piezometers are recorded in Table 11.

Measurements to calculate VHG were recorded on December 31, 2002, and May 19, 2003. The third measurement of VHG was scheduled for the end of spawning, however, this coincided with the sampling at the end of December. In addition to these formal measurements, a visual check for VHG was made and recorded at each mini-piezometer when DO and temperature values were made on several sampling days. These results are reported in Table 12 (a comment of "yes" indicates up-welling, "no" indicates no difference, or "down" indicating down-welling) for the dates when only visual checks were made. Initially, an electronic water-sensing tape measure was used to measure the water levels. However, this proved to be very problematic in the small diameter mini-piezometers, and its use was discontinued. As a precaution, marks indicating height above the top row of holes in the mini-piezometer were scored and labeled on the outside so that water heights could be measured with a metric tape. A small stilling well was used when water current made readings difficult.

Water velocities were measured using a digital current meter once adults were placed in the channels, and then monthly through May. Measurements were taken in front of each weir and, on several occasions, at the confluence of the south channel with the middle channel (Table 13.) During the months when grates or fry traps were in place at the weirs, these were thoroughly cleaned and any head created was allowed to recede before measurements were recorded.

Staff gauges were placed on the upstream side of both weirs on November 21, 2002. No attempt was made to set the two gauges to read equal heights in relation to each other. Survey measurements were taken on January 9, 2003, to determine the difference in height of the staff gauges. Corresponding heights on the two gauges differed by an estimated 0.88 feet, with the north weir being lower. This difference is due to elevation differences in the two channels. Staff gauges were placed so that measurements recorded allowed comparison of water depth at the weir slots. Staff gauge heights were recorded on an every-other-day basis when adult chum were present, during the incubation period, and then daily once fry trapping began (Table 14). During the months when grates or fry traps were in place at the weirs, these were thoroughly cleaned and any head created allowed to recede before measurements were recorded. The readings reported in Table 14 were corrected for the differences made in water heights due to grates, fry traps and sand bag placement for fry trapping.

Table 10. Mean Water Temperature Values from Mini-Piezometer Sampling, 2002-03.

South Channel		Mini-Piezometer #								
Date	Top	1	2	3	4	5	6	7	8	Bottom
11/29/2002	Dry									Dry
12/19/2002	9.00	8.80	8.90	9.20	9.20	8.90	9.00	9.00	8.90	8.90
12/31/2002	9.30	9.23	9.20	9.30	9.30	9.30	9.30	9.27	9.27	9.30
01/15/2003	Dry	Dry	Dry	Dry	9.27	Dry	Dry	9.07	8.90	8.90
01/29/2003	8.40	8.43	Dry	8.57	8.70	8.60	8.70	8.60	8.60	8.60
02/18/2003	8.80	8.47	8.40	8.50	8.50	8.50	8.63	8.50	8.57	8.50
03/03/2003	8.40	8.47	8.50	8.30	8.40	8.50	8.50	8.60	8.57	8.50
03/17/2003	8.30	8.20	8.27	8.30	8.40	8.40	8.70	8.50	8.50	8.40
04/02/2003	8.40	8.60	8.50	8.80	8.70	8.70	8.90	8.80	8.80	8.80
04/14/2003	8.40	8.70	8.70	8.70	8.90	9.00	9.00	9.00	9.20	9.00
04/28/2003	9.20	8.90	8.70	8.60	8.70	9.20	9.00	8.80	8.80	8.60
05/15/2003	8.70	8.60	8.50	8.60	8.60	8.60	8.70	8.60	8.70	8.70

Middle Channel		Mini-Piezometer #				
Date	Top	1	2	3	4	5	Bottom
11/29/2002	6.60						Dry
12/19/2002	9.30	8.90	8.90	9.00	9.00	8.80	8.90
12/31/2002	9.10	9.10	9.10	9.20	9.30	9.30	9.30
01/15/2003	8.80	8.80	8.77	8.70	8.87	8.83	8.90
01/29/2003	8.50	8.50	8.50	8.67	8.57	8.60	8.60
02/18/2003	8.30	8.60	8.50	8.70	8.70	8.70	8.80
03/03/2003	8.50	8.70	8.60	8.70	8.60	8.67	8.70
03/17/2003	8.50	8.80	8.70	8.80	8.80	8.80	8.40
04/02/2003	8.50	8.90	8.90	8.90	8.80	9.00	8.80
04/14/2003	8.70	9.00	9.10	9.20	9.20	9.60	9.20
04/28/2003	8.80	9.00	9.10	9.00	8.90	9.00	8.70
05/15/2003	8.90	9.00	8.90	8.90	8.80	8.90	8.90

North Channel		Mini-Piezometer #				
Date	Top	1	2	3	4	Bottom
11/29/2002	8.80					8.60
12/19/2002	8.90	8.90	-----	8.70	8.40	8.80
12/31/2002	7.70	8.47	-----	8.20	7.90	7.80
01/15/2003	8.00	7.90	-----	8.33	7.77	7.90
01/29/2003	7.50	7.60	-----	8.17	7.60	7.60
02/18/2003	8.20	7.90	-----	8.20	8.10	8.80
03/03/2003	8.10	7.90	-----	8.30	8.10	8.10
03/17/2003	8.00	8.10	-----	8.30	8.40	8.20
04/02/2003	8.50	8.30	-----	8.70	9.00	8.80
04/14/2003	8.70	8.70	-----	9.10	9.10	9.20
04/28/2003	8.70	8.80	-----	8.90	8.90	8.70
05/15/2003	8.70	8.70	8.90	8.80	8.80	8.80

Table 11. Mean DO Values from Mini-Piezometer Sampling, 2002-03

South Channel	Mini-Piezometer #									
Date	Top	1	2	3	4	5	6	7	8	Bottom
11/29/2002	Dry									Dry
12/19/2002	8.33	8.95	9.22	9.48	7.98	8.66	8.74	8.13	9.18	9.40
12/31/2002	9.54	10.73	10.99	10.76	9.91	10.83	10.50	10.40	10.53	7.99
01/15/2003	Dry	Dry	Dry	Dry	9.00	Dry	Dry	9.24	9.24	10.80
01/29/2003	9.89	10.44	Dry	10.61	10.58	10.98	9.73	10.44	10.15	10.07
02/18/2003	10.14	9.29	11.17	10.05	11.33	10.20	10.73	9.41	10.13	10.64
03/03/2003	10.61	7.24	10.39	6.65	10.77	5.87	7.23	5.35	7.96	11.14
03/17/2003	10.23	4.48	8.80	6.67	10.76	10.78	8.82	8.29	8.78	9.97
04/02/2003	10.23	7.90	8.16	7.68	11.05	7.71	9.87	9.19	9.27	9.83
04/14/2003	10.11	7.28	8.78	6.18	10.85	6.59	10.00	9.16	10.24	10.59
04/28/2003	10.13	4.58	8.22	6.38	10.54	4.49	9.24	8.07	10.56	9.79
05/15/2003	9.35	2.42	8.48	3.01	7.81	7.49	8.19	7.61	8.48	10.76

Middle Channel	Mini-Piezometer #					
Date	Top	1	2	3	4	5	Bottom
11/29/2002	13.17						Dry
12/19/2002	8.29	8.66	6.52	8.74	8.66	8.64	10.22
12/31/2002	9.33	8.66	7.77	9.41	8.72	5.59	8.32
01/15/2003	8.64	9.49	8.35	9.78	9.60	7.54	11.07
01/29/2003	10.12	10.30	9.48	10.78	10.62	7.30	10.56
02/18/2003	9.62	8.79	8.27	10.65	8.99	7.09	11.50
03/03/2003	9.99	9.42	7.71	8.91	7.66	6.84	11.85
03/17/2003	9.53	7.28	7.49	9.35	6.37	6.31	10.79
04/02/2003	8.96	6.46	4.83	5.65	5.49	5.06	9.88
04/14/2003	9.30	6.89	4.95	6.83	6.76	3.32	10.77
04/28/2003	9.22	7.70	8.98	11.90	11.46	3.31	10.73
05/15/2003	11.20	8.77	9.16	7.77	9.65	1.60	11.19

North Channel	Mini-Piezometer #					
Date	Top	1	2	3	4	Bottom
11/29/2002	10.88					11.85
12/19/2002	10.00	7.87	-----	9.31	10.12	11.02
12/31/2002	8.44	8.61	-----	7.94	8.46	8.66
01/15/2003	9.53	9.90	-----	10.68	10.82	10.39
01/29/2003	10.07	7.36	-----	9.83	9.15	11.02
02/18/2003	10.06	9.31	-----	7.55	7.81	11.82
03/03/2003	10.26	11.22	-----	10.17	10.31	11.05
03/17/2003	10.02	10.53	-----	10.22	10.30	10.49
04/02/2003	9.55	8.68	-----	6.68	8.97	9.96
04/14/2003	10.26	10.55	-----	11.31	11.94	12.00
04/28/2003	10.13	11.01	-----	13.17	13.33	10.33
05/15/2003	10.41	10.09	12.86	10.79	11.99	11.98

Table 12. Results of VHG Sampling, both Measured and Visual, 2002-03

South Channel Date	Mini-Piezometer # 1	2	3	4	5	6	7	8
12/31/2002	0.00	0.00	0.00	0.11	0.00	0.01	0.00	0.02
01/29/2003	No	No	No	Yes	No	No	No	No
02/18/2003	No	No	No	Yes	No	No	No	No
03/03/2003	No	No	No	Yes	No	No	No	No
03/17/2003	No	No	Yes	Yes	No	Yes	No	No
04/02/2003	No	No	No	Yes	No	Yes	No	No
04/14/2003	No	No	No	Yes	No	No	No	No
04/28/2003	No	No	No	Yes	No	No	No	No
05/15/2003	No	No	Yes	Yes	No	Yes	No	Yes
05/19/2003	0.00	0.02	0.09	0.02	0.00	0.01	0.00	0.00

Middle Channel Date	Mini-Piezometer # 1	2	3	4	5
12/31/2002	0.15	0.00	0.09	0.03	0.50
01/29/2003	Yes	No	Yes	Yes	Yes
02/18/2003	Yes	Yes	Yes	Yes	Yes
03/03/2003	Yes	No	Yes	Yes	Yes
03/17/2003	Yes	No	Yes	Yes	Yes
04/02/2003	Yes	No	Yes	Yes	Yes
04/14/2003	Yes	No	Yes	No	Yes
04/28/2003	Yes	No	Yes	No	Yes
05/15/2003	Yes	No	Yes	Yes	Yes
05/19/2003	0.13	0.00	0.07	0.01	0.90

North Channel Date	Mini-Piezometer # 1	2	3	4
12/31/2002	0.02	-----	0.01	0.00
01/29/2003	No	-----	No	No
02/18/2003	No	-----	No	No
03/03/2003	No	-----	No	No
03/17/2003	Yes	-----	No	No
04/02/2003	Yes	-----	No	No
04/14/2003	Yes	-----	No	No
04/28/2003	Yes	-----	No	No
05/15/2003	Yes	Yes	No	No
05/19/2003	0.07	0.00	0.00	0.00

Table 13. Water Velocity Measurements (fps) at the two Weirs in the Duncan Spawning Channels.

Date	South Weir	North Weir	South Channel Confluence
11/21/2002	0.000	0.227	----
12/20/2002	0.084	0.289	0.115
12/31/2002	0.147	0.487	0.368
01/29/2003	0.079	0.370	----
03/03/2003	0.185	0.202	0.441
04/02/2003	0.165	0.184	0.426
04/28/2003	0.193	0.108	0.810

Table 14 Staff Gauge Heights Recorded at the Two Weirs, 2002-03.

Date	South	North	Date	South	North	Date	South	North	Date	South	North
11/21/2002	0.82	0.60	02/14/2003	0.77	0.99	03/23/2003	0.97	0.98	04/25/2003	0.85	0.98
11/23/2002	0.77	0.55	02/15/2003	0.78	1.00	03/24/2003	0.95	0.94	04/26/2003	0.88	0.97
11/26/2002	0.35	0.66	02/16/2003	0.78	1.04	03/25/2003	0.92	1.08	04/27/2003	0.86	0.95
11/27/2002	0.30	0.70	02/17/2003	0.79	0.96	03/26/2003	0.83	1.16	04/28/2003	0.81	0.86
11/29/2002	0.00	0.60	02/18/2003	0.82	1.06	03/27/2003	0.92	1.13	04/29/2003	0.79	0.88
12/01/2002	0.00	0.30	02/19/2003	0.83	1.12	03/28/2003	1.07	1.10	04/30/2003	0.77	0.88
12/03/2002	0.00	0.00	02/20/2003	0.84	1.05	03/29/2003	0.89	1.17	05/01/2003	0.79	0.85
12/12/2002	0.80	0.66	02/21/2003	0.88	0.94	03/30/2003	0.93	0.95	05/02/2003	0.75	0.86
12/19/2002	0.84	0.69	02/22/2003	0.89	1.03	03/31/2003	0.89	0.88	05/03/2003	0.77	0.90
12/22/2002	0.82	0.65	02/23/2003	0.88	1.02	04/01/2003	1.12	1.18	05/04/2003	0.77	0.90
12/24/2002	0.76	0.61	02/24/2003	0.84	0.93	04/02/2003	1.01	1.08	05/05/2003	0.73	0.88
12/26/2002	---	---	02/26/2003	0.83	0.98	04/03/2003	0.90	1.21	05/06/2003	0.74	0.81
12/28/2002	0.75	0.66	02/27/2003	0.82	0.92	04/04/2003	0.95	1.24	05/07/2003	0.74	0.82
12/30/2002	0.82	0.68	02/28/2003	0.81	1.00	04/05/2003	0.93	1.22	05/08/2003	0.71	0.80
12/31/2002	0.84	0.66	03/01/2003	0.81	1.06	04/06/2003	1.01	1.08	05/09/2003	0.70	0.82
01/02/2003	0.80	0.64	03/03/2003	0.80	1.10	04/07/2003	0.95	1.13	05/10/2003	0.70	0.82
01/04/2003	0.82	0.76	03/04/2003	0.81	1.00	04/08/2003	0.91	1.12	05/11/2003	0.75	0.85
01/06/2003	0.86	0.94	03/05/2003	0.81	1.00	04/09/2003	1.09	1.18	05/12/2003	0.74	0.84
01/09/2003	0.72	0.71	03/06/2003	0.84	0.98	04/10/2003	1.06	1.10	05/13/2003	0.71	0.82
01/11/2003	0.70	0.62	03/07/2003	1.12	1.12	04/11/2003	0.92	1.10	05/14/2003	0.71	0.82
01/13/2003	0.69	0.62	03/08/2003	1.03	1.06	04/12/2003	0.99	1.12	05/15/2003	0.70	0.82
01/15/2003	0.64	0.52	03/10/2003	0.97	0.95	04/13/2003	0.89	1.04	05/16/2003	0.71	0.82
01/17/2003	0.64	0.67	03/11/2003	0.94	0.96	04/14/2003	0.91	1.05	05/17/2003	0.71	0.84
01/20/2003	0.62	0.66	03/12/2003	0.93	1.02	04/15/2003	0.92	1.00	05/18/2003	0.70	0.85
01/22/2003	0.61	0.65	03/13/2003	0.92	0.99	04/16/2003	0.96	1.10	05/19/2003	0.67	0.84
01/24/2003	0.64	0.66	03/14/2003	0.92	1.06	04/17/2003	0.91	0.98	05/20/2003	0.67	0.84
01/27/2003	0.76	0.73	03/15/2003	0.92	0.96	04/18/2003	0.90	0.95			
01/29/2003	0.73	0.71	03/17/2003	0.90	0.90	04/19/2003	0.95	0.98			
01/31/2002	2.28	2.37	03/18/2003	0.89	0.91	04/20/2003	0.89	0.98			
02/03/2003	0.92	1.09	03/19/2003	0.90	0.92	04/21/2003	0.83	0.94			
02/05/2003	0.90	1.06	03/20/2003	0.89	0.91	04/22/2003	0.80	0.93			
02/07/2003	0.82	1.04	03/21/2003	0.91	0.90	04/23/2003	0.88	0.96			
02/10/2003	0.78	NA	03/22/2003	0.90	0.98	04/24/2003	0.81	0.94			

Discussion

Weather conditions during the fall and winter of 2002-03 exposed several weaknesses in the Duncan Creek spawning channels design. During the fall months, low rainfall resulted in sub-surface water levels for extended periods in all three channels. This undoubtedly resulted in some loss of production from the desiccation of eggs in shallow redds. Additionally, receding water levels necessitated removal of adults from the channels which were then artificially spawned at Washougal Hatchery. More information about low fall water levels can be found in **Part III: Natural Spawning**. On January 31, 2003, a storm resulted in rainfall amounts sufficient to push Duncan Creek out of its banks and into the top end of two of the spawning channels (the middle and north). Duncan Creek has previously done this since the channels were renovated. In the early winter of 2002, heavy rainfall pushed Duncan Creek out of its banks and into the spawning channels. Afterward, a natural material berm was installed to re-direct flow on the corner where the creek had come overland. In mid-April of 2002, heavy rainfall again pushed the creek out of its banks during the fry trapping period and the water went around the newly installed berm. In 2003, water levels rose allowing Duncan Creek to go around, then over, the berm. Large amounts of water cascaded over the edges of the north and middle channels creating two large scour holes in the middle channel and significant gravel movement at the top of the north channel. The gravel movement in the north channel covered and filled in the hole the adults had dug during the fall when the water level receded into the gravel (Figure 8), and deposited a layer of fine sediment over the gravel (Figure 9). Scour holes were created at the top of the middle channel and directly below the weir (Figures 10 and 11). While the scour hole at the top was of minimal concern, the hole below the weir was substantial in size (estimated to be 10' long x 8' wide x 5' deep) and its formation deposited enough gravel downstream to form a long, shallow riffle.

This scour hole had to be filled before trapping could begin at this weir. Fill material was provided by the Burlington Northern Santa Fe Railway Company. The same storm necessitated excavation/re-enforcement around the bridge crossing Duncan Creek. The hole was filled in with several large (50-150 pound) boulders to form a solid base, then backfilled with smaller boulders and gravel from the downstream riffle.

Gravel sampling, scheduled to be completed in October of 2003 after this report is finalized, will provide a better measure of the winter storms impact on the gravel in the channels. This information will be reported in the 2004 Annual Report. However, the 2003 egg-to-fry survival rates in both channels indicate that channel gravel incubation conditions remained favorable after the storm.

Figure 8. Top of North Channel Showing Gravel Movement after January 2003 Storm.

Figure 9. Sediment Deposited in the North Channel by Overland Flows during the January 2003 Storm

Figure 10. Scour Hole Created at the Top of the Middle Channel by Overland Flow from Duncan Creek during the January 2003 Storm

Figure 11. Scour Hole Created Below the Middle Channel Weir during January 2003 Storm

As mentioned above, no usable data were recovered from the temperature loggers in the spawning channels. Temperatures recorded from inside the mini-piezometers and mid-water values measured at the top and bottom of each channel ranged from 7.5 to 9.3 ^{o}C, well above the 2.2 ^{o}C minimum that can negatively impact spawning and incubation (Schroder 1973; Koski 1975). DO levels recorded in the mini-piezometers of the middle and north channels in or near areas where spawning took place varied over the season but remained at or above acceptable levels. The dramatic decrease in DO levels measured in mini-piezometer #5 of the middle channel at the end of the season was not a concern. As this piezometer was located just upstream of the weir and no spawning took place in this area. DO levels in the surface water next to this piezometer were always at acceptable levels. This piezometer also had extreme upwelling evident (at times the difference in inside versus outside water levels was greater than 30cm) and it is unclear if this influenced the DO levels in the piezometer.

Continued monitoring of the hyporheic zone including temperature, gravel composition, hydraulic gradients, and DO levels will continue to ensure that the incubation environment in the Duncan Creek channels is suitable for this ESA-listed species. Re-establishment of a Duncan Creek spawning population will help reduce risks to LCR chum salmon.

Part III: Natural Spawning

Introduction

Re-colonization by adults straying from the LG population or the capture and release of LG population adults into the channel were the two primary means of initiating natural spawning in the Duncan Creek spawning channel. Adult chum captured in Duncan Creek could either be placed above the weirs in the spawning channels to reproduce naturally, or transported to the Washougal Hatchery for use in a hatchery supplementation program. The reproductive success of adults placed in the spawning channels, a is estimated by evaluating egg-to-fry survival rates. To evaluate egg-to-fry survival rates in naturally spawning fish, two estimates of egg deposition are needed: Potential Egg Deposition (PED) and Actual Egg Deposition (AED), and the total number of fry captured at each channel's weir. As detailed in the Duncan M&E, egg-to-fry survival rates should exceed 40% if the channels were constructed and being maintained correctly and female densities remain at less than one female per three square meters.

PED relies on relationships between phenotypic traits such as length or body weight, to estimate the fecundity of an individual female. Body size/fecundity relationships have been developed by researchers for several salmonid species (see Pritchard 1937; Rounsefell 1957; Allen 1958; Donaldson and Menasveta 1961; Gray 1965; Smolei 1966; Kato 1978; Gall and Gross 1978; Schroder 1981). These researchers showed that 10 to 70% of the variation in fecundity could be explained with female size (length or weight). Schroder (unpublished data) was able to explain 95% of the variation in fecundity of artificially spawned Grays River chum in 1998 and 1999 by using multiple regression analyses of log body weight, egg weight and transformed reproductive effort (total egg mass weight/total body weight). While egg weight and length data can be collected from live fish, reproductive effort requires that the fish be spawned artificially. Removal of the reproductive effort value reduced the amount of variance that could be explained. Replacing reproductive effort with a K value (weight/length cubed) in the regression models resulted in formulas that could explain 67 to 94% of the variation associated with fecundity. The Duncan M&E recommends artificially spawning 30-50 females to develop regression formulas that can be used to predict fecundity. Multiple years of data must be collected on artificially-crossed females of the LG population to develop these fecundity relationships and to measure yearly variation. AED equals PED minus any potentially viable (not deformed or still firmly attached to the ovarian membrane) eggs retained by the female at death. This is simply measured by sampling the females soon after death (< 24 hours) and counting potentially viable eggs.

Success of adults spawning in the channels can also be measured by estimating the number of returning adults from natural matings that occurred in the Duncan Creek spawning channels, the fry-to-adult survival rate called for in the LCR chum recovery strategy. This requires that all fry be trapped when migrating out of the spawning channels and marked for identification as adults. Lastly, adult chum returning to spawn from Bonneville Dam downstream to the I-205 bridge would need to be sampled for Duncan Creek project marks and an estimation of adult abundance in the different spawning locations made. Unfortunately, juveniles trapped in 2003 were not marked with strontium (Sr) as recommended in the Duncan M&E due to lack of required permits to apply and dispose of the strontium, thereby preventing any estimates of fry-to-adult survival rates of those chum salmon naturally produced in the spawning channels in 2002.

Methods

Adults placed into the channels were collected by WDFW and PSMFC from known local chum spawning areas using tangle nets. Adults selected to be placed above the weirs were placed into a fish tube as described in the hatchery section earlier in this report. If the fish needed to be transported, a 400-gallon truck-mounted tank was used. Numbered Floy anchor-dart tags (Floy Tag & Manufacturing, Inc., Seattle WA.), one on each side of the dorsal, were applied on all adults moved into the spawning channels above the weirs. Weekly spawning ground surveys of Duncan Creek and the channels below the weirs were conducted by PSMFC beginning November 7, 2002, and ending on January 3, 2003. All adult chum observed, dead or alive, were enumerated and biological samples were collected on all post-spawn mortalities. Biological sampling included: taking tissue samples for genetic analysis, scales for aging, lengths (fork (mm) and mid-eye-to-hypural plate (mm)) and the number eggs retained in the females. The sex, location and tag number(s), if present, were also recorded. WDFW and PSMFC conducted additional daily surveys above the weirs to collect these data on post-spawn mortalities of adults.

Estimation of the PED for each female placed in the spawning channels would ideally be calculated by multiple regression formulas using body weight, egg size and K. If egg size was unknown for an individual female because all of her eggs were deposited, formulas using body weight and K or just body weight, whichever explains the greatest amount of variation, would be used. Regardless of the formula, 95% confidence intervals were calculated and three values (expected, maximum and minimum) were developed for each female. These individual values were summed creating an expected, maximum and minimum PED for each channel.

Data to calculate values of AED for individual females were collected during daily surveys above the weirs. Egg size would be measured by randomly collecting up to ten eggs from any female found with viable retained eggs. These eggs would be placed in water, refrigerated for 24 hours, blotted dry and individually weighed to the nearest milligram. Because egg size has been shown to vary little within a female, (modal coefficient of variation for Grays River females equaled 2.5%) even a sample of one or two eggs can be used to determine egg size (Duncan M&E). After sampling, the carcass was removed from the channel and placed into the riparian zone of Duncan Creek to constrain pathogens and maintain DO levels in the channels.

Enumeration of out-migrating fry was done with downstream migrant traps at two weirs, put into place during channel construction. When operated properly, we expect that the weirs will be 100% efficient in capturing juveniles, and the outmigration will be a count rather than an estimate. One weir is below two channels, the south and middle, the other is below the north channel (Figure 6). Two differently designed traps were used to capture the migrating fry in 2003. Initially, the trap located at the north weir consisted of a nylon mesh net acting as a flume to deliver fish into a live box (Figure 12), and was the same design used in 2002. Because this trap design failed in 2002, (the mesh net's zipper broke on the peak outmigration day) fence-panel weir traps were used in 2003. Unfortunately, not all the fence-panel weir components had arrived when the trap was initially installed at the north weir and a mesh net flume was installed for the beginning of the trapping season until it could be replaced. The fence-weir panels were available and installed initially at the south weir when trapping began (Figure 13). Two groups of marked fry were released above each weir to calculate trap efficiency.

Traps were checked daily by either WDFW or PSMFC. All trapped fish were enumerated and released each day, mortalities and their location (on fence panels/fyke net or in live box) were recorded. Up to thirty randomly-chosen fry from each channel were weighed (0.01 g) and measured (fork length) every Monday, Wednesday and Friday. These values were used to calculate K_D values (Bams 1970) for individual fish.

Figure 12. Mesh Net Fry Trap Initially Installed at the North Weir.

Figure 13. Fence Panel-Weir Fry Trap Operated at the South Weir.

Results

A total of 13 chum were observed (12 live and one dead) during five spawning ground surveys conducted below the weirs of the channels and in Duncan Creek between November 21 and December 26, 2002. Because no adult trap was operated at the mouth of Duncan Creek during the 2002 adult migration period, the exact number of adult chum and other salmonids that volitionally entered Duncan Creek is unknown. Rawding and Hillson (2003) reported that the LG chum population (Ives Island and Multnomah groups, excluding tributary spawners) for the fall of 2002 was 5,514 (95% CI 4,958 – 5,994), yielding an observed stray rate (13/5,514) of 0.2 percent. This extremely low rate is not surprising given the low water conditions present in the Columbia River and Duncan Creek during the fall of 2002.

Sixty-five adults (32 females and 33 males) were released above the weirs into the Duncan Creek spawning channels. Tables 15 and 16 detail the locations were adult chum placed into the spawning channels were collected. The number of adults to be placed in each channel was determined prior to the adult collection season in 2002. However, low water conditions forced the plan to be abandoned. Rainfall amounts were the fourth and fifth lowest recorded since 1940, in the months of October and November, 2002, respectively. It wasn't until November 20 that a sufficient amount of rainfall had occurred to provide water in either channel deep enough to begin placing adults above the weirs. By December 1, lack of additional rainfall lowered the water level above the south weir to below the gravel. Only two pair of adults were placed above the south weir before water levels receded. The north channel is at a slightly lower elevation (approximately 0.9 feet at the weir) relative to the south weir and the water level didn't completely drop below the gravel until December 9. Twenty-three pairs of adults had been placed into the north channel before water levels receded. As the water level dropped in this channel the adults dug at the bottom and sides of the channel displacing all the new spawning gravel and reaching dirt in one area of the upper channel (Figure 14, the hand drawn line indicates normal water height), this picture was taken on December 9. On December 7, all the remaining live adults, four male and nine female, were removed from the north channel and taken to Washougal Hatchery to be spawned. These adults contributed an estimated 13,600 fry to the hatchery program. Complete biological data, fecundity and green egg-to-release survival rates for these fish can be found in the **Results** section of **Part I: Duncan Creek Chum Salmon Hatchery Program**. The water level in this channel also eventually decreased to below the gravel (Figure 15). Rainfall returned on December 10, and both channels returned to normal water levels by December 12. Three pre-spawn mortalities (based on the number of retained eggs), one in the middle and two in the north channel, were recovered prior to December 7. No additional adults were placed into the north channel so that the effects of the dewatering could be measured via the egg-to-fry survival rate for that channel. No production was expected from the two pairs placed above the south weir in November as there had been no measurable rainfall amounts above a trace recorded in Portland for 20 days and the water level in this channel remained below the gravel for 10 days. Therefore, additional adults (seven females and eight males) were placed above the south weir on December 20.

All adults placed above the weirs in the channels were double Floy tagged and their fork lengths recorded prior to release. The south channel received 19 adults (9 female, 10 males) and the north channel received 46 adults (23 female and 23 male). No adults escaped from above the weirs in 2002.

Biological data collected during spawning-ground surveys above the weirs is summarized in Table 17. Three scales were taken from each fish for age determination. Age-3 fish dominated the age structure of males placed above the weirs, 55% age-3, 42% age-4 and 3% age-5 (Figure 16). The age composition of females placed above the weirs was similar to those spawned at the hatchery, 30% age-3 and 70% age-4 (Figure 16). A comparison of average fork and mid-eye-to-hypural lengths by age and sex can be found in Table 18. Fork lengths for age-3 females ranged from 620 mm to 730 mm, averaging 681 mm, and age-4 females ranged from 676 mm to 811 mm, averaging 731 mm (Figure 17). Fork lengths for age-3 males ranged from 696 mm to 810 mm, averaging 744 mm, and age-4 males ranged from 742 mm to 869 mm, averaging 806 mm. The one age-5 male had a recorded fork length of 827 mm (Figure 18). The number of retained viable eggs for females that died from causes other than low water ranged from zero to 218, averaging 59 (n=8). No data were collected on egg size of females found with retained eggs as there was no scale available with the precision needed to make these measurements in the fall of 2002.

Figure 14. Top of the North Channel showing hole dug by adults as water levels receded, dark line indicates normal water depth, December 12, 2002.

Figure 15. Water Level in the North Channel, December 9, 2002.

Table 15. Adult Seining Data, 2002.

Date	Location	# Salmonids Caught Chum	Chinook	Coho
11/06/02	Hamilton Slough	23		
11/13/02	Hamilton Bay/Pocket	34	3	27
11/14/02	Woods' Landing and Rivershore	21		
11/18/02	Multnomah Creek	66		
11/18/02	Hamilton Bay/Pocket	48	2	
11/19/02	Woods' Landing and Rivershore	62		
11/20/02	Hamilton Bay/Pocket	48	2	1
11/25/02	Hamilton Bay/Pocket	127		
11/25/02	Multnomah Creek	125		
11/26/02	Hamilton Bay/Pocket	134		
11/27/02	Rivershore	16		
12/02/02	Hamilton Bay/Pocket	194		
12/02/02	Multnomah Creek	139		
12/03/02	Woods' Landing and Rivershore	326		
12/05/03	Hamilton Bay/Pocket	305		
12/05/02	Top of Pierce Island	54		
12/09/02	Hamilton Bay/Pocket	254		
12/09/02	Top of Pierce Island	72		1
12/09/02	Bottom of Ives Island	24		
12/11/02	Multnomah Creek	102		
12/13/02	Woods' Landing and Rivershore	173		
12/16/02	Hamilton Bay/Pocket	97		
12/16/02	Top of Pierce Island	11		
12/16/02	Bottom of Ives Island	9		
12/17/02	Woods' Landing and Rivershore	248		
12/18/02	Multnomah Creek	68		
12/18/02	Saint Cloud area (Goodbear/Archer)	2		
12/20/02	Woods' Landing and Rivershore	291		
12/23/02	Multnomah Creek	17		

Table 16. Date of Capture and Origin of Adult Chum Moved to Duncan Creek Channels, 2002.

			Duncan Creek Channels			
			Above South Weir		Above North Weir	
Date	Location	Number Adult Chum Seined	Male	Female	Male	Female
11/20/02	Hamilton Bay/Pocket	48	1	1	3	3
11/26/02	Hamilton Bay/Pocket	134	1	1	10	10
12/02/02	Hamilton Bay/Pocket	194			10	10
12/20/02	Woods' Landing and Rivershore	291	8	7		
	Total		10	9	23	23

Table 17. Biological Data of Adults Placed in Spawning Channels, 2002-03.

Date Released	Date Sampled	Sex	North or South Channel	Age	Fork Length (cm)	Mid-Eye-to-Hypural (cm)	# of eggs retained	Comments
20-Nov	3-Dec	F	South	4	770	605	0	Dewatered in channel
20-Nov	3-Dec	M	North	4	808	610		
20-Nov	3-Dec	M	South	3	720	547		Dewatered in channel
20-Nov	5-Dec	M	North	4	815	595		Dewatered in channel
20-Nov	7-Dec	F	North	4	721	590	11	Dewatered in channel
20-Nov	7-Dec	M	North	4	869	540		Dewatered in channel
20-Nov	-------	F	North	---	739	-------	-------	Skeleton found 1/4/03 in bushes
20-Nov	-------	F	North	---	714	-------	-------	Skeleton found 2/1/03 in bushes
26-Nov	29-Nov	M	South	3	750	545		Dewatered in channel
26-Nov	1-Dec	M	North	3	715	544		
26-Nov	1-Dec	M	North	3	740	550		
26-Nov	3-Dec	F	South	3	675	540	1,746	Dewatered in channel
26-Nov	4-Dec	M	North	5	827	623		
26-Nov	6-Dec	F	North	4	735	570	0	Dewatered in channel
26-Nov	6-Dec	F	North	4	695	555	0	Dewatered in channel
26-Nov	6-Dec	M	North	4	805	593		Dewatered in channel
26-Nov	6-Dec	M	North	3	705	535		Dewatered in channel
26-Nov	7-Dec	F	North	4	725	576	46	Dewatered in channel
26-Nov	7-Dec	F	North	4	722	575	11	Dewatered in channel
26-Nov	7-Dec	F	North	4	811	645	2	Dewatered in channel
26-Nov	7-Dec	F	North	4	679	632	1	Dewatered in channel
26-Nov	7-Dec	F	North	3	661	516	24	Dewatered in channel
26-Nov	7-Dec	F	North	4	710	547	0	Dewatered in channel
26-Nov	7-Dec	F	North	4	738	578	1	Dewatered in channel
26-Nov	7-Dec	M	North	3	782	585		Dewatered in channel
26-Nov	7-Dec	M	North	3	758	565		Dewatered in channel
26-Nov	7-Dec	M	North	4	805	605		Dewatered in channel
26-Nov	7-Dec	M	North	4	771	565		Dewatered in channel
26-Nov	-------	F	North	3	635	515	NA	Spawned at Washougal Hatchery
26-Nov	-------	M	North	3	696	545		Spawned at Washougal Hatchery
2-Dec	6-Dec	F	North	3	710	555	2,912	Dewatered in channel
2-Dec	6-Dec	M	North	4	868	645		Dewatered in channel
2-Dec	7-Dec	M	North	3	810	597		Dewatered in channel
2-Dec	7-Dec	M	North	4	829	603		Dewatered in channel
2-Dec	7-Dec	M	North	3	748	563		Dewatered in channel
2-Dec	7-Dec	M	North	4	818	607		Dewatered in channel
2-Dec	7-Dec	M	North	3	765	581		Dewatered in channel
2-Dec	7-Dec	M	North	3	711	548		Dewatered in channel
2-Dec	-------	F	North	3	730	598	NA	Spawned at Washougal Hatchery
2-Dec	-------	F	North	4	724	588	NA	Spawned at Washougal Hatchery
2-Dec	-------	F	North	4	725	570	NA	Spawned at Washougal Hatchery
2-Dec	-------	F	North	3	680	545	NA	Spawned at Washougal Hatchery
2-Dec	-------	F	North	3	620	500	NA	Spawned at Washougal Hatchery
2-Dec	-------	F	North	3	719	553	1,299	Dewatered in channel
2-Dec	-------	F	North	4	740	595	NA	Spawned at Washougal Hatchery
2-Dec	-------	F	North	4	711	573	NA	Spawned at Washougal Hatchery
2-Dec	-------	F	North	4	755	610	NA	Spawned at Washougal Hatchery
2-Dec	-------	M	North	3	784	600		Spawned at Washougal Hatchery
2-Dec	-------	M	North	3	715	560		Spawned at Washougal Hatchery
26-Nov	7-Dec	M	North	3	782	585		Dewatered in channel
2-Dec	-------	M	North	3	755	580		Spawned at Washougal Hatchery
20-Dec	24-Dec	F	South	4	754	565	71	
20-Dec	24-Dec	F	South	4	750	585	52	
20-Dec	26-Dec	F	South	4	775	694	8	
20-Dec	26-Dec	F	South	3	695	542	0	
20-Dec	26-Dec	M	South	4	820	592		
20-Dec	26-Dec	M	South	3	745	548		
20-Dec	28-Dec	M	South	4	755	563		
20-Dec	28-Dec	M	South	3	743	550		
20-Dec	28-Dec	M	South	4	742	555		
20-Dec	30-Dec	F	South	4	721	572	281	
20-Dec	30-Dec	F	South	4	720	569	1	
20-Dec	30-Dec	F	South	4	676	530	3	
20-Dec	30-Dec	M	South	4	821	613		
20-Dec	31-Dec	M	South	4	758	587		
20-Dec	2-Jan	M	South	3	745	555		

Table 18. Average Fork Length (cm) and Mid-Eye-to-Hypural Lengths (cm) by Sex and Age of Adults Placed Above Spawning Channel Weirs, 2002.

Sex	Age	N=	Avg. Fork Length (cm)	Avg. Mid-Eye-to-Hypural (cm)
Male	3	18	74.4	56.1
	4	14	80.6	59.1
	5	1	82.7	62.3
	Combined	33	77.3	57.6
Female	3	9	68.1	54.0
	4	21	73.1	58.7
	Combined	30	71.7	57.9

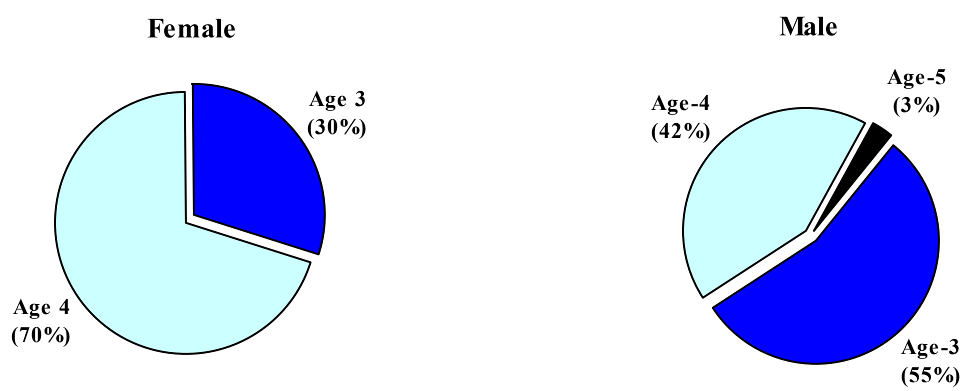

Figure 16. Age Composition of Adult Chum Sampled in the Duncan Creek Spawning Channels, 2002.

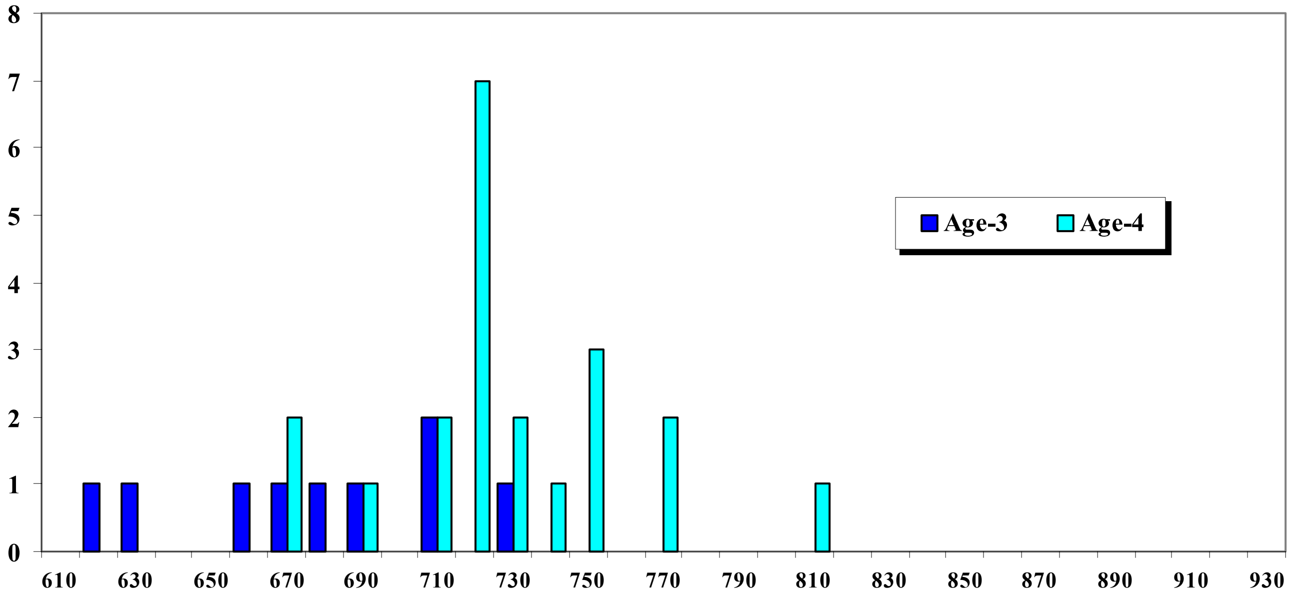

Figure 17. Fork Lengths of Female Chum Placed in the Duncan Creek Spawning Channels, grouped by age and 10 mm increments, 2002.

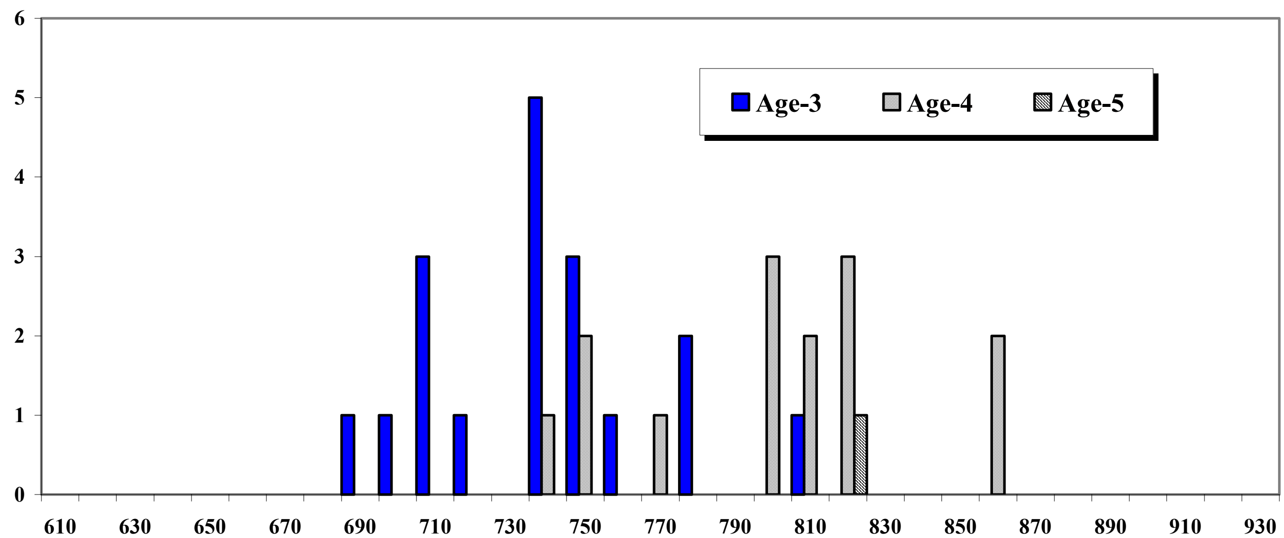

Figure 18. Fork Lengths of Male Chum Placed in the Duncan Creek Spawning Channels, grouped by age and 10 mm increments, 2002.

Females spawned at Washougal Hatchery were used to create predictive regression formulas to estimate PED of females who spawned naturally in the channels. Individual reproductive values (total egg mass weight (g) / body weight (g)) were calculated for all females spawned at the hatchery. Females with reproductive values less than 16% have likely lost eggs or already spawned at least once in the river before capture (Steve Schroder, pers. comm.) and were not included in the regression analysis. Another female (#2) was excluded because her eggs were found to be non-viable when shocked, resulting in 59 sets of data for the regression analysis (only 17 sets were available in 2002).

Using only fork length in the regression resulted in a significant relationship ($R^2 = 0.48$, ANOVA $P \leq 0.05$), this regression was not significant in 2002 ($R^2 = 0.10$). A regression analysis by age group, using Log10 fork length yielded better results for age-3 fish. Log10 fork lengths, grouped by age, were able to explain 58% (ANOVA $P \leq 0.05$) of the variation in fecundity of age-3, but only 39% (ANOVA $P \leq 0.05$) of the variation in age-4 females. Multiple regression using Log10 fork length and age was able to explain 48% (ANOVA $P \leq 0.05$) of the variation of both age groups. The best relationships were used to calculate age-3 and age-4 female PED values, age-3 Log10 fork lengths and all ages Log10 fork lengths respectively. Lastly, mean fecundity by age was calculated. Confidence intervals (95%) were calculated for all significant regressions and the mean fecundities by age to yield expected, maximum, and minimum PED values for each female that spawned in the channels. These values were summed to create the expected, maximum, and minimum PED of each channel (Table 19).

Table 19. PED Values (expected, maximum and minimum) for the Duncan Creek Channels by method, 2003.

	Predictive Fecundity Regression Formulas		
Channel	Expected	Maximum	Minimum
South	27,700	30,460	24,940
North	67,922	75,242	60,602
Total	95,622	105,701	85,541
	Using Mean Fecundity by Age Group		
Channel	Expected	Maximum	Minimum
South	27,241	30,611	23,870
North	69,017	77,791	60,244
Total	96,258	108,402	84,114

The number of retained eggs is known for the seven females that spawned above the south weir and did not encounter low water conditions (Table 17). These values were converted to percent-retained eggs using the individual expected fecundity values derived from the predictive regression formula. The mean of these percentages (1.92%) was used as the retention rate for the two females that were recovered as skeletons late in the season. The mean value was used to give each sample value equal weight. This allowed AED values (expected, maximum, and minimum) to be calculated for each channel (Table 20). Because female fish were removed on December 7 from the north channel, and taken to Washougal hatchery to be spawned, the number of eggs taken at the hatchery from those females was subtracted from the channel PED values. Since it was unlikely that the two females who spawned above the south weir in November would contribute to fry production, their PED and AED values were removed from that channel's total as well.

Table 20. AED Values (expected, maximum and minimum) for the Duncan Creek Channels by method, 2003.

Channel	Expected	Maximum	Minimum
		Predictive Fecundity Regression Formulas	
South	21,603	23,671	19,535
North	45,468	49,746	41,190
Total	67,071	73,417	60,725
		Using Mean Fecundity by Age Group	
Channel	Expected	Maximum	Minimum
South	21,363	23,937	18,788
North	46,351	55,124	37,577
Total	67,713	79,061	56,366

The number of fry captured in the Duncan Creek traps was used in conjunction with AED values to calculate expected, maximum, and minimum egg-to-fry survival rates for the two channels. Fry trapping began at the north weir on February 10. Initially, a mesh net trap was installed (Figure 12). As in 2002, the zipper on the net failed on March 17. However, no fry were lost since the zipper failed as it was being closed. A new net was substituted in the same day with no trapping time loss. On April 3, the mesh net was replaced with a fence-weir trap (Figure 13). Fry trapping did not begin until March 25 at the south weir. As mentioned in **Part II: Monitoring of the Physical Attributes of the Spawning Channels**, heavy rainfall at the end of January pushed Duncan Creek overland and into the spawning channels. This created a large scour hole directly downstream of the south weir (Figure 11). This scour hole prevented trap placement until the scour hole was filled. There was no urgency to fill the hole since all production from the two pairs planted in November was assumed to be lost, and temperature data indicated fry emergence from adults planted in late December would not begin until April 1. However, upon installation the trap began collecting fry immediately, indicating production from the early pairs. Both traps were monitored daily until their removal on May 21.

A total of 24,938 chum fry (9,023 and 15,915 south and north weir traps respectively) were recovered from the two traps (Table 21). Daily trapping totals and cumulative percent passage at each weir are graphically displayed in Figures 19 and 20. In addition to chum fry, a few coho (age 0+ and 1+), one cutthroat trout and three trout/steelhead parr were trapped/seined at the weirs (Table 22). Daily trapping totals are reported in Appendix A. On May 20 and 21, the channels were seined and an additional 540 fry (376 above the south and 164 above the north) were recovered above the weirs. Some fry production from above the south weir was not enumerated due to the late initiation of trapping at that weir. Random samples of 30 fry trapped in the first two days had average fork lengths greater than 41.5 mm, indicating that they must be from the two pairs of adults placed in the channel in November.

There were two releases of marked fish above the traps to estimate trapping efficiency. The first, on April 10, consisted of 60 fry marked with Bismarck Brown dye (immersion in a solution of approximately 1:65,000 for 30 minutes), 30 above each weir. Only seven of the 60 released (six at the south weir trap and only one at the north weir trap) were reported recovered, yielding trapping efficiencies of 20% and 3%, south and north traps respectively. While this mark is very evident initially (Figure 21), it fades over a few weeks time and becomes unrecoverable. The second release, April 28, was again 30 fry above each weir. These fry were marked by excising a portion of their upper caudal fin. Only nine of the 60 released (three at the south weir trap and six at the north weir trap) were recorded, yielding trap efficiency rates for the south and north weir traps of 10% and 20% respectively. However, eight caudal clipped fry were recovered while seining on May 20 indicating, that they were residing in the channels and not outmigrating directly after emergence. Therefore, juvenile trapping totals were not expanded by any trap efficiency rates.

A total of 199 mortalities were recovered at the two traps, 27 and 172 south and north weirs respectively, resulting in an overall season mortality rate of 0.79% (Appendix A Table 1). The majority of the mortalities recorded at the north weir (120 of the 172) were recovered during a period of 10 days after the mesh net was replaced with fence weir panels. Having the live box already in place resulted in shorter weirs, less dewatering area and higher water velocities across the fence weir panels. Modifications were made to the fence panels and sand bag placement to alleviate this problem, and mortality rates decreased. The trap at the south weir had daily mortality rates for chum fry ranging from 0 to 33% with an overall season rate of 0.29%. The trap at the north weir had daily rates ranging from 0 to 100% with an overall season rate of 1.07% for chum fry. The highest daily mortality rates for both traps occurred on days with collection totals of only three fry. Three mortalities were recovered during seining at the end of the trapping season, bringing the total to 202.

Table 21. Number of Chum Fry Trapped and Seined from the Duncan Creek Channels, 2003.

	Chum Fry		
	Alive	Dead	Total
South Weir Trap	8,996	27	9,023
North Weir Trap	15,743	172	15,915
Trapping Total	24,739	199	24,938
Seining	537	3	540
Combined	25,276	202	25,478

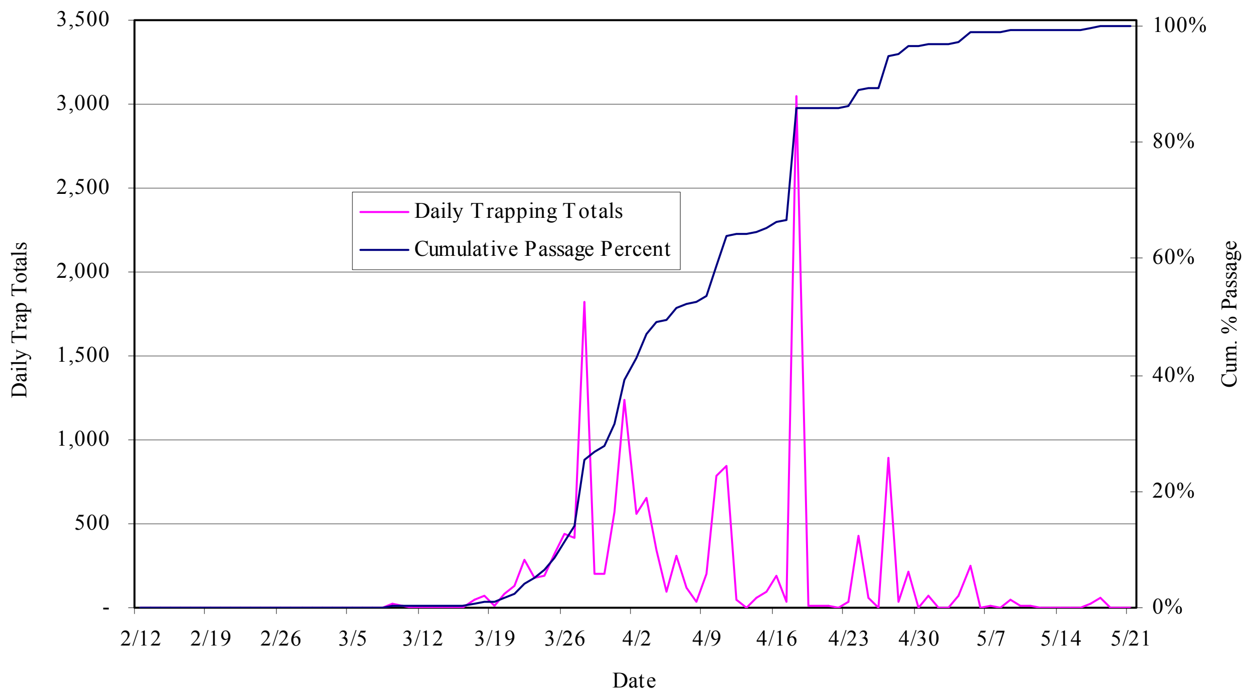

Figure 19. Daily Collection Totals of Chum Fry at the North Weir in the Duncan Creek Spawning Channels, 2003.

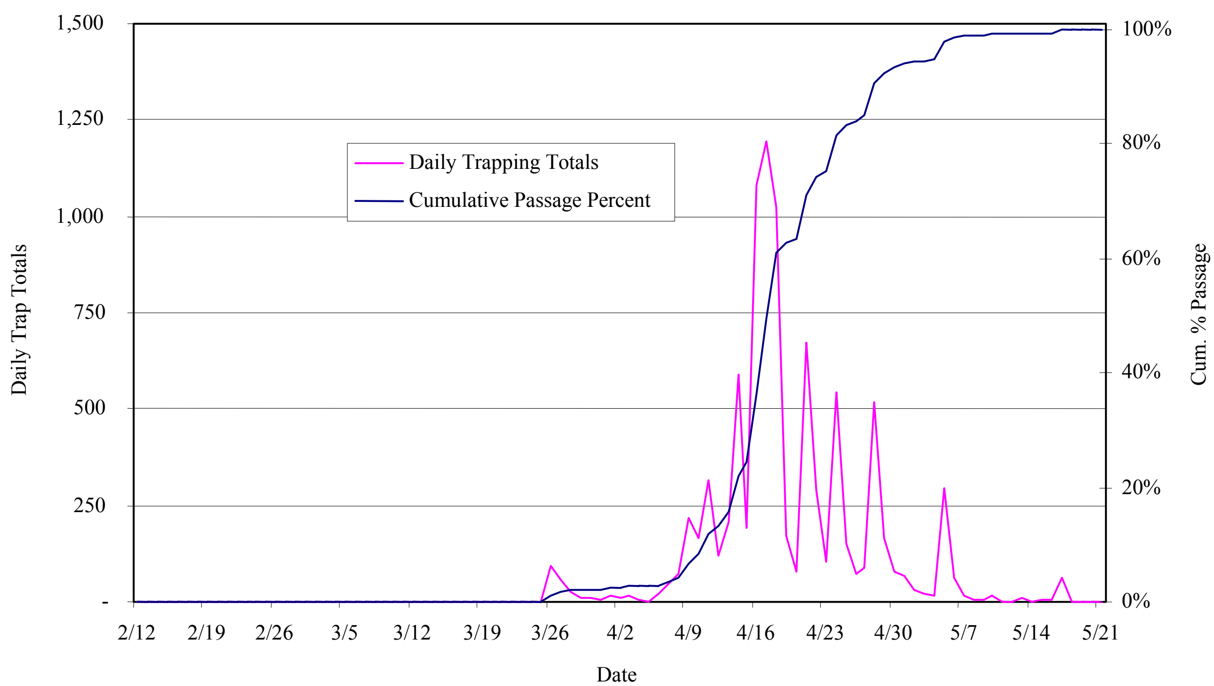

Figure 20. Daily Collection Totals of Chum Fry at the South Weir in the Duncan Creek Spawning Channels, 2003.

Figure 21. Chum Fry Marked with Bismark Brown (top) and a Non-Marked Chum Fry (bottom) for Comaprision.

Table 22. Number of Other Salmonids Trapped from the Duncan Creek Spawning Channels, 2003.

	Coho				
	Age 0+	Age 1+	Total	Cutthroat	Steelhead/trout
South Weir Trap	3	1	4	1 (143 mm)	2 (210 & 220 mm)
North Weir Trap	7	2	9		
Seining	40	0	40		
Combined	50	3	53	1	2

Individual weight and length data was collected on a maximum of 30 out-migrating fry from each trap at least three times a week, normally on Monday, Wednesday and Friday, throughout the season. Results of this sampling are presented in Table 23.

Table 24 details the egg-to-fry survival rates calculated using the AED estimates (expected, maximum, and minimum) from the predictive formulas, and mean fecundity rates. The number of fry used in these rates is the actual number trapped with no expansion estimates done.

Table 23. Daily Average Weights, Fork lengths and K_D Values with 95% CI of Chum Fry at the Two Traps, 2003.

South Weir Trap						North Weir Trap					
Date	Average Weight (g)	Mean FL (mm)	n=	K_D	+/-	Date	Average Weight (g)	Mean FL (mm)	n=	K_D	+/-
26-Mar	0.48	41.63	30	1.87	0.06	7-Mar	0.46	38.60	5	2.00	0.07
27-Mar	0.52	41.73	30	1.92	0.06	8-Mar	0.43	38.25	4	1.96	0.14
28-Mar	0.51	42.00	27	1.91	0.07	10-Mar	0.44	38.71	7	1.97	0.08
29-Mar	0.56	42.50	10	1.94	0.09	11-Mar	0.50	38.50	2	2.06	0.22
1-Apr	0.48	41.71	14	1.87	0.05	12-Mar	0.60	40.00	1	2.11	----
2-Apr	0.47	41.78	9	1.85	0.08	14-Mar	0.55	39.50	2	2.07	0.30
3-Apr	0.49	41.92	13	1.88	0.04	15-Mar	0.45	39.50	4	1.94	0.13
4-Apr	0.48	40.75	4	1.91	0.14	17-Mar	0.48	40.03	30	1.95	0.09
5-Apr	0.60	45.00	2	1.88	0.33	18-Mar	0.49	40.13	30	1.96	0.07
7-Apr	0.49	41.37	30	1.90	0.10	19-Mar	0.47	40.00	10	1.94	0.07
8-Apr	0.42	39.93	30	1.87	0.07	20-Mar	0.48	40.30	30	1.94	0.09
9-Apr	0.42	39.93	30	1.87	0.05	21-Mar	0.46	40.03	30	1.92	0.07
11-Apr	0.42	39.93	30	1.87	0.07	24-Mar	0.47	40.67	30	1.90	0.08
14-Apr	0.45	40.33	30	1.90	0.10	26-Mar	0.51	40.67	30	1.96	0.06
16-Apr	0.43	39.87	30	1.89	0.06	28-Mar	0.47	40.70	30	1.91	0.05
18-Apr	0.48	41.07	30	1.90	0.07	2-Apr	0.46	41.20	30	1.87	0.06
21-Apr	0.48	41.47	30	1.88	0.08	4-Apr	0.41	39.87	30	1.86	0.07
23-Apr	0.47	42.10	30	1.84	0.06	7-Apr	0.42	40.13	30	1.86	0.10
25-Apr	0.41	40.13	30	1.85	0.10	8-Apr	0.43	40.10	30	1.87	0.08
28-Apr	0.50	42.70	30	1.84	0.10	11-Apr	0.43	39.50	30	1.90	0.06
30-Apr	0.50	42.47	30	1.84	0.09	14-Apr	0.43	40.00	30	1.87	0.10
2-May	0.62	45.93	28	1.84	0.10	16-Apr	0.45	40.93	30	1.87	0.07
5-May	0.83	47.73	30	1.94	0.09	18-Apr	0.43	40.60	30	1.86	0.07
7-May	0.67	45.18	17	1.91	0.09	21-Apr	0.36	39.29	7	1.80	0.09
9-May	0.70	44.50	4	1.94	0.24	23-Apr	0.43	40.40	30	1.86	0.09
16-May	1.23	52.00	3	1.97	0.28	25-Apr	0.46	41.43	30	1.85	0.07
20-May	1.42	55.27	30	2.01	0.05	28-Apr	0.41	39.63	30	1.86	0.09
						5-May	0.64	43.63	30	1.96	0.08
						7-May	0.56	42.79	14	1.90	0.10
						9-May	0.84	47.47	30	1.97	0.08
						16-May	0.23	38.33	3	1.60	0.08
						20-May	0.98	49.33	30	1.98	0.07

Table 24. Egg-to-Fry Survival Rates (expected, maximum and minimum) for the Duncan Creek Spawning Channels by Method, 2003.

	Predictive Fecundity Regression Formulas		
Channel	Expected	Maximum	Minimum
South	43.51%	39.71%	48.11%
North	35.27%	32.25%	38.92%
Total	37.99%	34.70%	41.96%
	Using Mean Fecundity by Age Group		
Channel	Expected	Maximum	Minimum
South	44.00%	39.27%	50.03%
North	34.31%	28.85%	42.33%
Total	37.63%	32.23%	45.20%

Discussion

The stray rate into Duncan Creek for 2002 was estimated to be near 0.2%, this compares to a rate of near 1.0% in 2001. At these low rates, it would take many generations for the Duncan Creek spawning channel to reach maximum capacity. Therefore, supplementation and its evaluation should continue to ensure the rapid re-establishment of a spawning population in Duncan Creek.

Typical K_D values in chum salmon fry range from 1.8 to 2.0, (the higher the number the more yolk the fry still has present) values of ≤ 1.7 indicate emaciated fry. K_D values can be used to ascertain intra-gravel conditions. Poor intra-gravel conditions may result in premature fry emergence which would be reflected in higher than expected K_D values. No K_D values recorded for fry trapped at the weirs were equal to or below 1.8 in 2003.

The mean expected egg-to-fry survival rate was calculated at 35% for the north channel in 2003, comparing to estimated rates of 46 to 56% in 2002. The range in the 2002 survival rate was caused by estimating passage when traps were not operated, and a trap failure that necessitated an estimated number on the peak out-migration date. The 35% egg-to-fry survival rate for the north channel in 2003 is lower than the expected survival based on the 2002-03 physical habitat sampling, indicating rates could be 60% to 80%. However, given that the channel and eggs were subjected to severe low water levels during, and just after, spawning and then having Duncan Creek overflow it's banks during the winter resulting in overland flows, 35% was higher than expected. The 2003 rate should be considered a minimum and not reflective of the channel's potential since it is not possible to remove the effects of low water and flooding on egg survival.

The 2003 mean expected egg-to-fry survival rate of 44% for the middle channel is almost three times the rate estimated in 2002 of 17% (estimated due to incomplete trapping). This rate should be considered high as it assumes no production from the two November spawning pairs. The rate decreases to 39% if the AED values for the November females and estimated number of missed fry due to the late trapping start date (8.5% of the season total had passed the north weir before the south weir trap was installed) are included in the calculation. Assuming that the November pairs survived at a similar rate to the pairs in the north channel (35%), they produced approximately 1,500 fry. Removing these fry from the south weir trap total results in an egg-to-fry survival rate of 40% for the pairs released in late December.

Releases of marked fry above the weirs were made in 2003 to estimate trap efficiency over the course of the outmigration. However, incomplete recovery and faded marks due to fry residing above the traps before out-migrating made the releases useless. Only fin clips will be used in 2004 and the importance of recovering these marks will be emphasized to samplers. A more complete sampling of females that spawned in the channels and those spawned at Washougal Hatchery resulted in better prediction formulas for PED values and more accurate egg-to-fry survival rates in 2003 when compared to 2002. A scale was purchased in the spring of 2003 that will provide the accuracy (0.001 g) needed to measure individual egg size. Incorporating egg size into the 2003 predictive fecundity regression formulas along with age and Log10 fork length results in a much more accurate estimate ($R^2 = 0.99$, ANOVA $P \leq 0.01$).

A trap will be installed in early fall of 2003, at the dam structure on Duncan Creek to facilitate collection of adults for this program, providing a more accurate picture of migration timing and numbers of adult chum and other salmonids that volitionally enter Duncan Creek. This structure will also provide the opportunity to exclude other salmonid adults from entering Duncan Creek, thereby preventing predation on chum fry in the channels when they emerge. The steps needed to mark the trapped outmigrating fry with strontium will be completed prior to the 2004 out-migration. Uniquely marking the fry produced in the channels will allow estimates of straying rates, both into Duncan Creek by adults produced in other areas, and of Duncan Creek origin adults to other areas. Marking will also allow for an estimate of egg-or fry-to-adult survival rates.

Summary

Overall, the Duncan Creek chum project was a success again in 2002-03. Certain strengths and weaknesses were exposed (*e.g.* inadequate incubation and rearing space at Washougal Hatchery for any large salvage operation and an egg-to-fry survival rate of 35% for a channel that experienced both extremes in water levels), providing knowledge and experience that will improve program execution in future years.

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Appendix A

Daily Collection Numbers of Salmonids and Daily Percent Mortality for Age 0+ Chum at the Two Weirs in Duncan Creek, 2003

Table 1. Daily Collection Numbers of Salmonids and Daily Percent Mortality for Age 0+ Chum at the Two Weirs in Duncan Creek, 2003.

	South Weir							North Weir						
	Chum				Coho		Other	Chum				Coho		Other
	Age 0+				Age 0+	Age 1+		Age 0+				Age 0+	Age 1+	
Date	Live	Dead	Total	% Mort	Total	Total		Live	Dead	Total	% Mort	Total	Total	
12-Feb								0	0	0				
13-Feb								0	0	0				
14-Feb								0	0	0				
15-Feb								0	0	0				
16-Feb								0	0	0				
17-Feb								0	0	0				
18-Feb								0	0	0				
19-Feb								0	0	0				
20-Feb								0	0	0				
21-Feb								0	0	0				
22-Feb								0	0	0				
23-Feb								0	0	0				
24-Feb								0	0	0				
25-Feb								0	0	0				
26-Feb								0	0	0				
27-Feb				Trap not yet installed				0	0	0				
28-Feb								0	0	0				
1-Mar								0	0	0				
2-Mar								0	0	0				
3-Mar								0	0	0				
4-Mar								0	0	0				
5-Mar								0	0	0				
6-Mar								0	0	0				
7-Mar								5	0	5	0.00%			
8-Mar								4	0	4	0.00%			
9-Mar								19	0	19	0.00%			
10-Mar								7	0	7	0.00%			
11-Mar								2	0	2	0.00%			
12-Mar								1	0	1	0.00%			
13-Mar								0	0	0				

Table 1. Continued

	South Weir							North Weir						
	Chum				Coho		Other	Chum				Coho		Other
	Age 0+				Age 0+	Age 1+		Age 0+				Age 0+	Age 1+	
Date	Live	Dead	Total	% Mort	Total	Total		Live	Dead	Total	% Mort	Total	Total	
14-Mar								2	0	2	0.00%			
15-Mar								4	1	5	20.00%			
16-Mar								0	3	3	100.00%			
17-Mar								45	5	50	10.00%			
18-Mar								69	0	69	0.00%		1	
19-Mar				Trap not yet installed				10	2	12	16.67%			Trout fry, 78 mm
20-Mar								79	0	79	0.00%			
21-Mar								131	0	131	0.00%			
22-Mar								280	0	280	0.00%			
23-Mar								177	0	177	0.00%			
24-Mar								196	0	196	0.00%			
25-Mar								319	0	319	0.00%		1	
26-Mar	91	0	91	0.00%				438	3	441	0.68%			
27-Mar	55	0	55	0.00%				416	0	416	0.00%			
28-Mar	27	1	28	3.57%				1,825	2	1,827	0.11%			
29-Mar	11	0	11	0.00%				201	0	201	0.00%	4		
30-Mar	8	1	9	11.11%				198	1	199	0.50%	1		
31-Mar	5	1	6	16.67%				565	4	569	0.70%			
1-Apr	14	0	14	0.00%	1			1,239	2	1,241	0.16%			
2-Apr	9	0	9	0.00%				552	2	554	0.36%			
3-Apr	13	0	13	0.00%				648	7	655	1.07%			
4-Apr	4	0	4	0.00%	1			338	2	340	0.59%			
5-Apr	2	0	2	0.00%				64	31	95	32.63%			
6-Apr	21	1	22	4.55%				303	3	306	0.98%			
7-Apr	44	1	45	2.22%				113	1	114	0.88%			
8-Apr	74	0	74	0.00%				30	4	34	11.76%			
9-Apr	215	0	215	0.00%				194	5	199	2.51%			
10-Apr	162	2	164	1.22%				734	54	788	6.85%	1		
11-Apr	315	0	315	0.00%		1		841	0	841	0.00%			
12-Apr	118	0	118	0.00%				33	13	46	28.26%			

Table 1. Continued

	South Weir							North Weir						
	Chum				Coho		Other	Chum				Coho		Other
	Age 0+				Age 0+	Age 1+		Age 0+				Age 0+	Age 1+	
Date	Live	Dead	Total	% Mort	Total	Total		Live	Dead	Total	% Mort	Total	Total	
13-Apr	207	2	209	0.96%				3	1	4	25.00%			
14-Apr	586	3	589	0.51%	1			50	4	54	7.41%			
15-Apr	192	0	192	0.00%				96	0	96	0.00%			
16-Apr	1,082	1	1,083	0.09%				185	2	187	1.07%			
17-Apr	1,191	3	1,194	0.25%				27	4	31	12.90%			
18-Apr	1,023	0	1,023	0.00%				3,042	7	3,049	0.23%	1		
19-Apr	169	0	169	0.00%				9	0	9	0.00%			
20-Apr	79	1	80	1.25%				8	0	8	0.00%			
21-Apr	674	1	675	0.15%				7	0	7	0.00%			
22-Apr	289	0	289	0.00%				0	0	0				
23-Apr	102	0	102	0.00%			Cutthroat, 143 mm	39	0	39	0.00%			
24-Apr	545	0	545	0.00%			Rainbow, 220mm	428	0	428	0.00%			
25-Apr	150	0	150	0.00%				61	0	61	0.00%			
26-Apr	73	0	73	0.00%				1	0	1	0.00%			
27-Apr	88	0	88	0.00%				890	3	893	0.34%			
28-Apr	513	3	516	0.58%				32	0	32	0.00%			
29-Apr	164	0	164	0.00%				218	1	219	0.46%			
30-Apr	79	0	79	0.00%				0	0	0				
1-May	67	0	67	0.00%				73	0	73	0.00%			
2-May	28	1	29	3.45%				0	0	0				
3-May	20	0	20	0.00%				4	1	5	20.00%			
4-May	17	0	17	0.00%				73	0	73	0.00%			
5-May	291	2	293	0.68%	1			243	2	245	0.82%			
6-May	63	1	64	1.56%				1	1	2	50.00%			
7-May	17	0	17	0.00%				14	0	14	0.00%			
8-May	4	0	4	0.00%				0	0	0				
9-May	4	0	4	0.00%				47	0	47	0.00%			
10-May	14	0	14	0.00%				7	0	7	0.00%			
11-May	0	0	0					11	0	11	0.00%			
12-May	0	0	0					0	0	0				

Table 1. Continued

	South Weir							North Weir						
	Chum				Coho		Other	Chum				Coho		Other
	Age 0+				Age 0+	Age 1+		Age 0+				Age 0+	Age 1+	
Date	Live	Dead	Total	% Mort	Total	Total		Live	Dead	Total	% Mort	Total	Total	
13-May	11	0	11	0.00%				1	0	1	0.00%			
14-May	0	0	0	0.00%				0	0	0				
15-May	2	1	3	33.33%			Rainbow, 210 mm	0	0	0				
16-May	3	0	3	0.00%				3	0	3	0.00%			
17-May	59	1	60	1.67%				29	0	29	0.00%			
18-May	2	0	2	0.00%				59	1	60	1.67%			
19-May	0	0	0					0	0	0				
20-May	0	0	0					0	0	0				
21-May	0	0	0					0	0	0				
Seining														
5/20	357	1	358	0.28%	30			155	2	157	1.27%			
5/21	18	0	18	0.00%	10			7	0	7	0.00%			
Total	9,371	28	9,399	0.30%	44	1	3	15,905	174	16,079	1.08%	7	2	1