B O N N E V I L L E   P O W E R   A D M I N I S T R A T I O N

Evaluation of Fall Chinook and Chum Salmon Spawning below Bonneville Dam

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Evaluation of Fall Chinook and Chum Salmon Spawning Below Bonneville Dam

Annual Report

October 2004 – September 2005

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ABSTRACT

Pacific salmon *Oncorhynchus* spp. populations have declined over the last century due to a variety of human impacts. Chum salmon *O. keta* populations in the Columbia River have remained severely depressed for the past several decades, while upriver bright (URB) fall Chinook salmon *O. tschawytscha* populations have maintained relatively healthy levels. For the past seven years we have collected data on adult spawning and juvenile emergence and outmigration of URB fall Chinook and chum salmon populations in the Ives and Pierce islands complex below Bonneville Dam. In 2004, we estimated 1,733 fall Chinook salmon and 336 chum salmon spawned in our study area. Fall Chinook salmon spawning peaked 19 November with 337 redds and chum salmon spawning peaked 3 December with 148 redds. Biological characteristics continue to suggest chum salmon in our study area are similar to nearby stocks in Hardy and Hamilton creeks, and Chinook salmon we observe are similar to upriver bright stocks. Temperature data indicated that 2004 brood URB fall Chinook salmon emergence began on 6 January and ended 27 May 2005, with peak emergence occurring 12 March. Chum salmon emergence began 4 February and continued through 2 May 2005, with peak emergence occurring on 21 March. Between 13 January and 28 June, we sampled 28,984 juvenile Chinook salmon and 1,909 juvenile chum salmon. We also released 32,642 fin-marked and coded-wire tagged juvenile fall Chinook salmon to assess survival. The peak catch of juvenile fall Chinook salmon occurred on 18 April. Our results suggested that the majority of fall Chinook salmon outmigrate during late May and early June, at 70-80 mm fork length (FL). The peak catch of juvenile chum salmon occurred 25 March. Juvenile chum salmon appeared to outmigrate at 40-55 mm FL. Outmigration of chum salmon peaked in March but extended into April and May.

INTRODUCTION

Columbia River chum salmon *Oncorhynchus keta* once numbered over one million fish, but have declined in the past century due to overexploitation, habitat degradation, and loss of spawning habitat due to hydroelectric activities (Nehlsen et al. 1991; Johnson et al. 1997; Hillson 2003). Chum salmon historically had the widest distribution of Pacific salmonids and composed up to 50% of the annual biomass (Salo 1991). Returns of chum salmon in the Columbia River were in decline by the late 1930s and had been extirpated from most tributaries by the 1950s. Currently, the Lower Columbia River evolutionarily significant unit (ESU) contains three stable natural populations of chum salmon, including Grays River, Hardy Creek and Hamilton Creek (Johnson et al. 1997). Persistent low numbers of chum salmon in the Lower Columbia River ESU prompted the National Oceanic and Atmospheric Administration (NOAA) to list them as threatened under the Endangered Species Act (ESA) in May 1999 (NOAA 1999).

Although populations of chum salmon have remained depressed in recent decades, some upriver bright (URB) fall Chinook salmon *O. tshawytscha* stocks have been relatively healthy. Since 2001, there have been three near record returns of fall Chinook salmon to the Columbia River (ODFW 2005). Historically, the URB fall Chinook salmon composed the largest proportion of the fall run (ODFW 2002). Chinook salmon spawning in the Hanford Reach of the Columbia River represent one of the largest and healthiest groups of URB stock (Nehlsen et al. 1991). Genetically similar groups have established viable populations outside their original geographic area. One example is the Ives / Pierce islands population, located approximately three km below Bonneville Dam (Figure 1; van der Naald et al. 2004). This is the only known wild URB fall Chinook salmon population in the lower Columbia River, and genetic analyses by the Washington Department of Fish and Wildlife (WDFW) indicated these fish are similar to upriver URB populations (WDFW, unpublished data).

The Ives / Pierce island complex includes a side channel between river kilometer (rkm) 228 and 229 and is described in further detail by Hoffman (2001) and Tiffan et al. (2005). This area is host to a significant amount of spawning activity for both fall Chinook and chum salmon (van der Naald et al. 2004). In the past decade, the U. S. Geological Survey (USGS), U. S. Fish and Wildlife Service (USFWS), Oregon Department of Fish and Wildlife (ODFW), Pacific States Marine Fisheries Commission (PSMFC), Battelle Pacific Northwest Natural Laboratories (PNNL), and WDFW have conducted research in this area focused on the monitoring and recovery of fall Chinook and chum salmon stocks.

As part of this effort we have observed, evaluated, and inventoried adult spawning and juvenile emergence for chum and Chinook salmon since the fall of 1998 (van der Naald et al. 2000). Each year we estimate peak spawning, run timing, and residence time of adult fish. We map chum and Chinook salmon redd locations with global positioning systems (GPS). We also derive population estimates for both chum and fall Chinook salmon by tagging carcasses, and collect biological data to describe vital statistics (e.g. age and gender ratios) and help determine stock origins. In the spring we estimate emergence timing, map distribution of juvenile fish, evaluate rearing behavior, and tag juvenile fall Chinook salmon with coded-wire tags (CWTs) to determine survival. The two primary objectives of this project are to: 1) search for evidence of fall Chinook and chum salmon spawning in the mainstem Columbia River below Bonneville Dam (Figure 1) and identify their stock origins, and 2) evaluate juvenile fall Chinook and chum salmon populations rearing in this area to determine emergence timing, spatial distribution, length frequencies, and outmigration timing. Specific tasks we conducted during this period included:

1) Documentation of fall Chinook salmon and chum salmon spawning naturally in the mainstem Columbia River below Bonneville Dam.

2) Collection of biological data to describe the stocks of fall Chinook and chum salmon.

3) Collection of coded-wire tags to determine stock origin of fall Chinook salmon.

4) Determination of emergence timing and hatching rate of juvenile fall Chinook and chum salmon.

5) Determination of outmigration timing and size for juvenile fall Chinook and chum salmon.

6) Determination of stock composition for juvenile fall Chinook salmon and chum salmon.

7) Estimation of juvenile to adult survival rate of fall Chinook salmon.

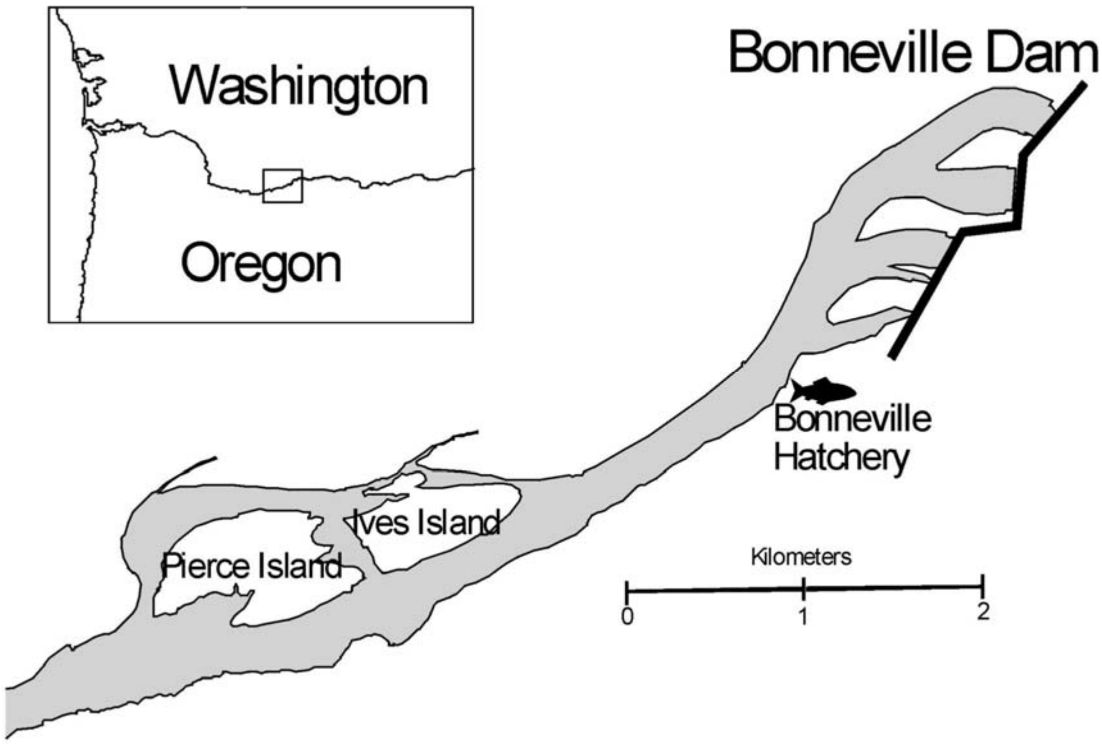

Figure 1. The Columbia River below Bonneville Dam.

This report describes work conducted by ODFW and PSMFC from 1 October 2004 to 30 September 2005.

METHODS

Adult Salmon Surveys

We began spawning ground surveys for fall Chinook and chum salmon below Bonneville Dam in October 2004; these continued twice weekly through December. The survey area included the shorelines of Pierce and Ives Islands and shorelines of the Columbia River that are adjacent to the islands (Figure 2). Primary spawning areas are within the island complex and along the shorelines of the islands adjacent to the main channel of the Columbia River. We divided the area into 13 sections. At each section, we counted redds and numbers of live and dead fish from the bow of a jet boat and by wading in shallow water. The locations of newly formed spawning redds were recorded with a differentially corrected GPS receiver.

We used a capture-recapture carcass tagging methodology to estimate populations of Chinook and chum salmon spawning below Bonneville Dam. Each week, we marked newly found carcasses with a colored plastic tag (on the underside of the operculum) and returned them to their original location. We recorded the number of newly assigned tags and the number of tags recovered from previous weeks. Carcasses found with a tag were severed at the caudal

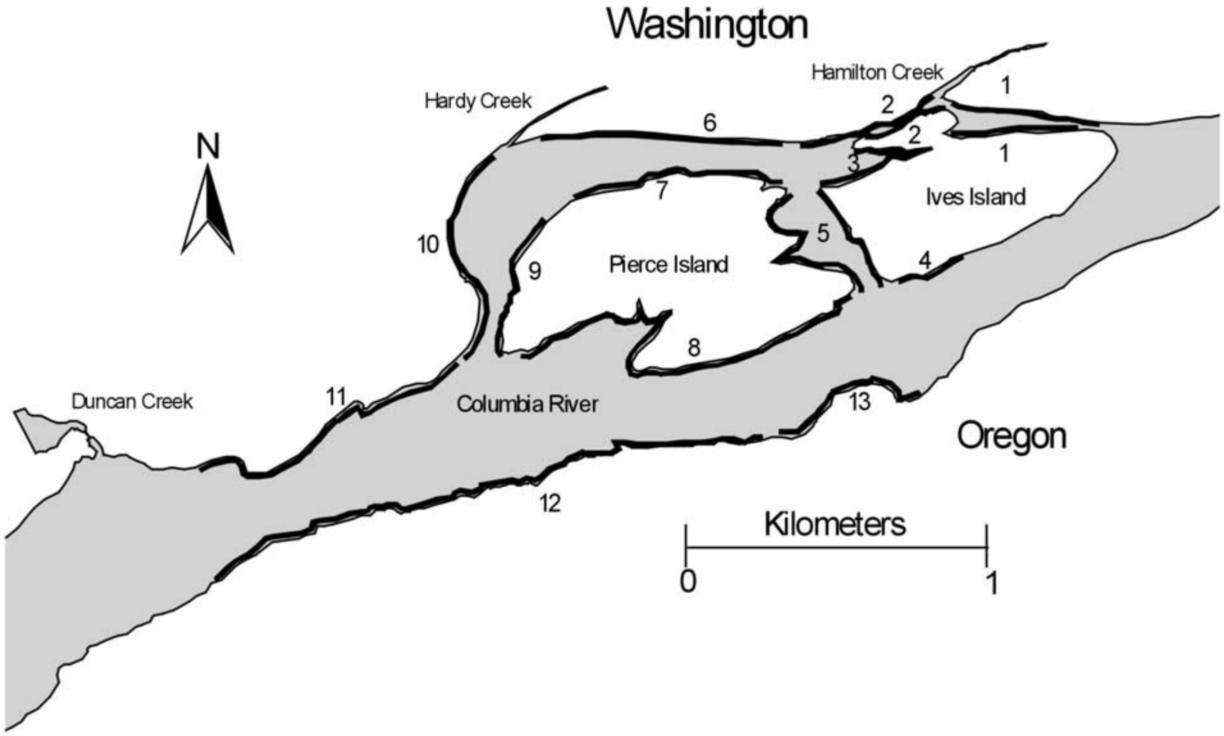

Figure 2. Survey areas for adult fall Chinook and chum salmon below Bonneville Dam, 2004.

peduncle to identify them as recoveries. Our field data was provided to WDFW, who calculated the population estimates using multiple release and recapture analyses (Rawding and Hillson 2002).

We collected biological data from fish carcasses to profile stocks for age composition, average size at return, and sex ratios. Scales from Chinook and chum salmon were removed and analyzed to determine age. To help determine stock origin of salmon found in the study areas, we inspected fall Chinook salmon carcasses for fin clips. The snouts of fish with adipose fin clips were removed and kept for future CWT recovery and analysis.

Juvenile Salmon Surveys

To help determine when to begin sampling for juvenile salmon we used temperature units (TU; Celsius degree-days) to estimate hatching and emergence dates. The dates were calculated in TU from the initiation of spawning to hatching of eggs (500 ^{o}C. TU for Chinook salmon and 600 ^{o}C. TU for chum salmon) and beginning and ending of emergence (1,000 ^{o}C. TU for Chinook salmon and 825 ^{o}C. TU for chum salmon). Chum salmon are known to hatch between 400 and 600 °C TU and complete yolk absorption between 700 and 1000 °C TU (Salo 1991); the Ives and Pierce island population seems to adhere to the TUs listed above.

To obtain the most accurate estimate for both species, we used readings from four different temperature gauge sites (Figure 3). Gauge 1 (G1) is located at the head of the Hamilton Channel area, near the tip of Ives Island. This gauge records temperatures within the water column and is representative of mainstem flows. For an accurate record of the temperatures within the Hamilton Channel, we used three additional gauges. Two of the three (T1LB and T2LB) are located on the left bank of the channel. The third gauge (T2MC) is located in the mid-channel adjacent to the uppermost left bank gauge.

Excluding G1, each site has two separate temperature sensors. The first sensor, located about 50 cm below the river bed, measures subsurface temperatures and is referred to as the "bed sensor". The second sensor records temperatures from the water column (the "river water sensor"). Both the bed and river water sensors are used to formulate a "redd pocket depth" temperature. We used these combined temperatures and those from as Gauge 1 as the basis for our emergence estimates. The three Hamilton Creek channel gauge sites are maintained by PNNL, who also provided the analyses of redd pocket depth temperatures (PNNL, unpublished data).

We surveyed for juvenile fish in areas where spawning occurred near Ives and Pierce islands (Figure 4). We used two gear types to capture juvenile fish. We fished shorelines with either 1.2-m deep stick seines with 3.2-mm mesh in lengths of 5.5 and 8.5 m, or a 30.5-m beach seine with 1.6-mm mesh. The seines were retrieved immediately after being deployed from the boat. In-water fishing time was approximately five minutes. We used beach seines most effectively in sections of the river that were free of snags and large obstructions, and had moderate flow velocities. Stick seines were employed where sampling was more difficult.

We placed captured fish into five-gallon buckets containing the anesthetic MS-222. Once anesthetized, they were identified to species, measured (fork length in mm) and examined for fin clips. Processing time was 5-10 minutes per set. After the data was collected, we released the fish at the site of capture, unless they were to be tagged. Some days we seined just to collect fish to tag; these fish were sorted by size, but were not measured. We also recorded starting and ending times for each sampling day, the number of sets fished, water temperature (^{o}C), and Bonneville Dam discharge (kcfs; Fish Passage Center 2005).

Some of the fish we collected migrated into our survey areas from upriver. Our criteria for differentiating unmarked, local, native Chinook salmon from unmarked hatchery releases and upriver natural production was based on fork length (FL). Through March, we assumed unmarked Chinook salmon < 60 mm FL were naturally produced from areas around Ives and Pierce islands. In the Columbia River system, hatcheries release Chinook salmon at sizes > 60 mm FL, and wild Chinook salmon do not begin migrating until they are larger than 60 mm FL (L. Basham, Fish Passage Center, personal communication).

To estimate the juvenile to adult survival rate for wild fall Chinook salmon we adipose fin-marked and coded-wire tagged a portion of the catch. We tagged fish during April and May when native Chinook salmon began reaching an acceptable minimum tagging size (47 mm FL; Norman 1987). To avoid tagging fish migrating from outside the area, we terminated tagging

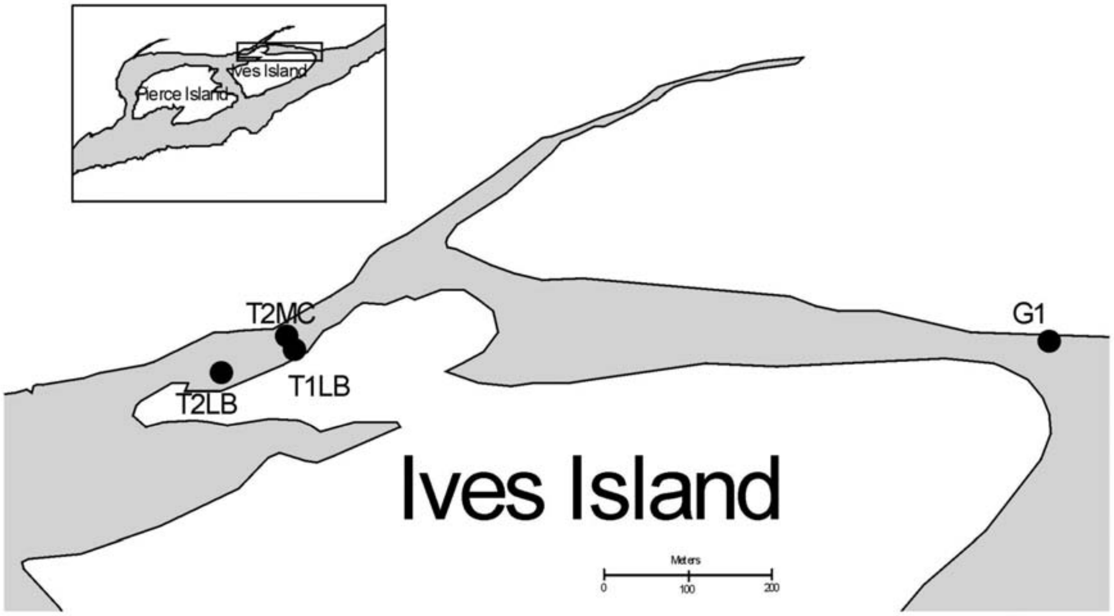

Figure 3. Location of temperature gauges (G1, T1LB, T2LB, and T2MC) at Ives Island.

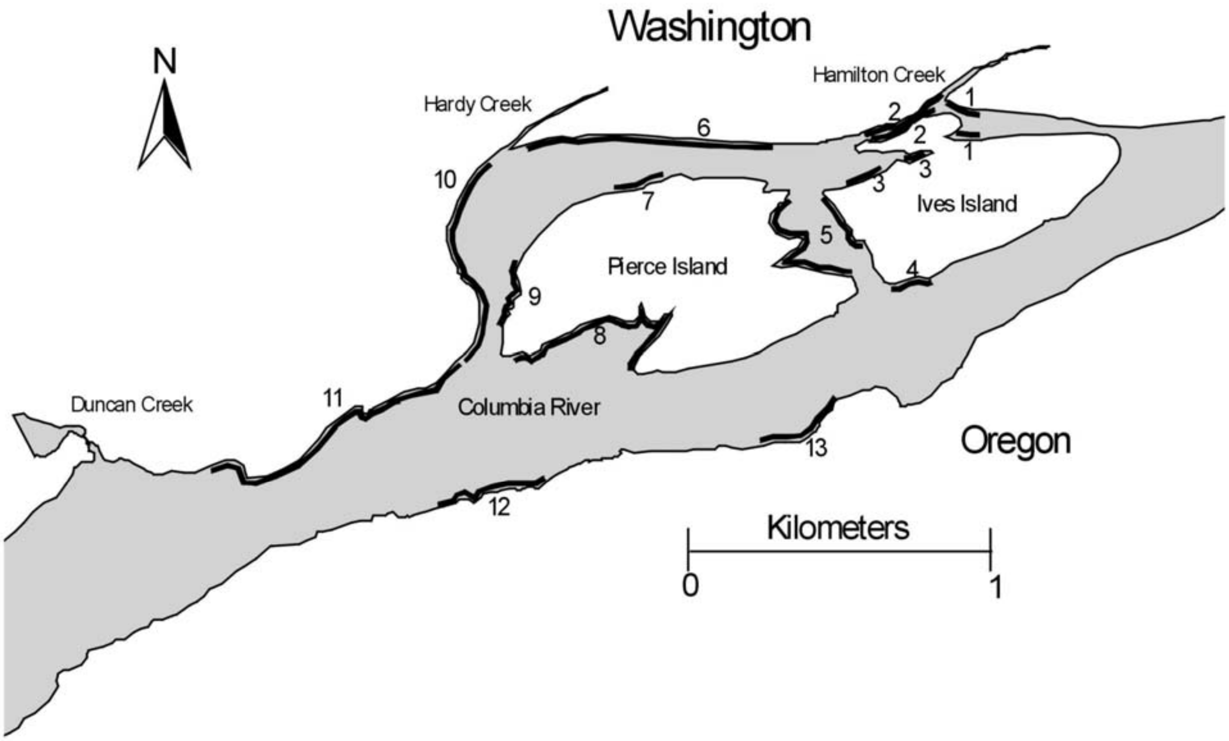

Figure 4. Survey sites for juvenile fall Chinook and chum salmon below Bonneville Dam, 2005.

when fin-marked fish of comparable size to the native population (>75 mm FL) began migrating into the area from above Bonneville Dam.

We held fish in a net pen for about 24 hours prior to tagging. They were then transported to the tagging site, anesthetized with MS-222, measured, sorted by length, adipose fin marked and tagged with a standard length CWT. After tagging, we checked each fish with a detector to confirm tag presence. We then placed the fish into a recovery tank for approximately 30 minutes prior to their transfer to an in-river holding pen.

Several times a day, we sacrificed a fish to check for proper tag placement. At the end of each day, we released the tagged fish into the Columbia River downstream of the study area. We held approximately 1% of all the tagged fish for 24 hours to check short-term tag retention and estimate short-term mortality.

RESULTS AND DISCUSSION

Adult Fall Chinook Salmon

Initiation of spawning below Bonneville Dam for bright stock fall Chinook salmon was 12 October 2004. Peak spawning occurred during the week of 15 November (Figure 5); we observed 471 live adults on 16 November and 337 redds on 19 November. The end of spawning for fall Chinook salmon could not be documented, as we observed 5 live fish and 36 redds on the last day of surveys (28 December).

We have conducted spawning ground surveys below Bonneville Dam for the past seven years (van der Naald et al. 2000, 2001, 2002, 2003, 2003b, 2004). Estimated peak spawning time for bright fall Chinook salmon has been as early as 9 November and as late as 24 November. This timing corresponds to other late-spawning stocks of fall Chinook salmon found in the Columbia River (Hansen and Cramer 1981).

In 2004, we found the majority of fall Chinook salmon redds above and below the mouth of Hamilton Creek, between Ives and Pierce islands, and in the main channel along the south side of Pierce Island (Sections 1, 2, 5, and 8, Figure 2; Figure 6). These areas have been frequently used by Chinook salmon in past years (van der Naald et al. 2000, 2001, 2002, 2003, 2003b, 2004).

From our field data, WDFW estimated 1,733 fall Chinook salmon returned to spawn in the areas around Ives and Pierce islands in 2004. This estimate is biased low, since fish were also observed spawning in the deeper main channel areas where carcasses could not be recovered. The estimated number of fish spawning in 2004 was greater than any other year except 2002 (Figure 7; van der Naald et al. 2003, 2004).

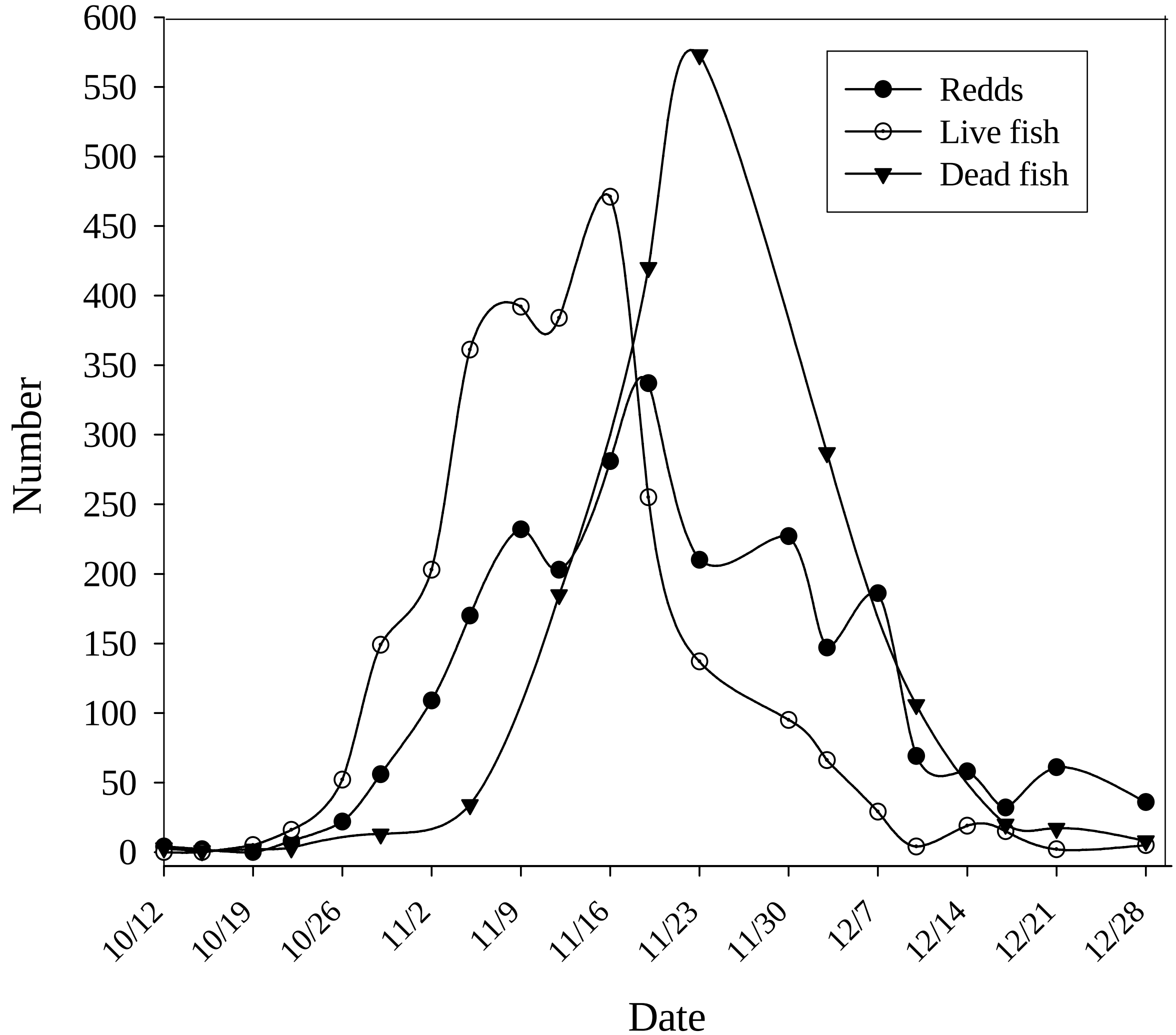

Figure 5. Number of live and dead Chinook salmon and Chinook salmon redds observed below Bonneville Dam by survey date, 2004.

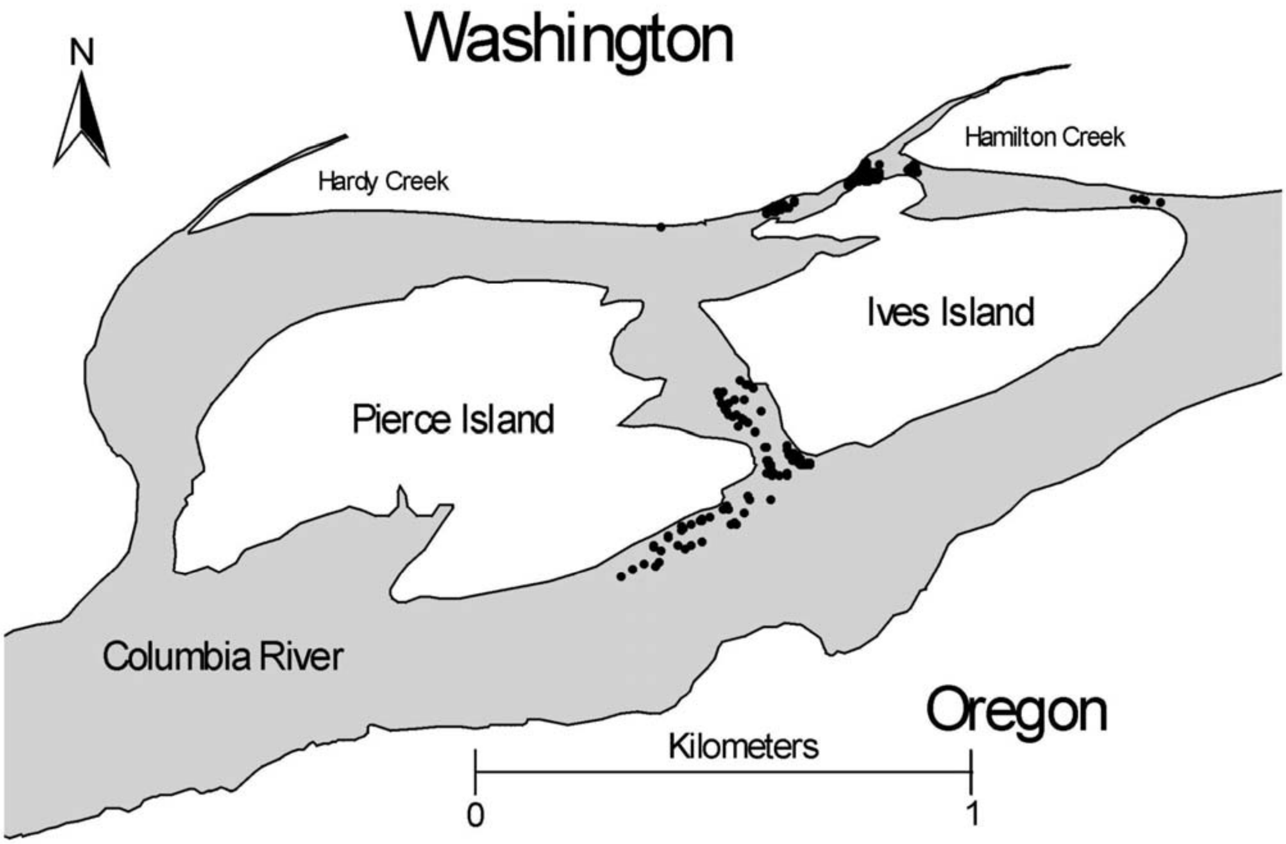

Figure 6. Locations (black circles) of fall Chinook salmon redds below Bonneville Dam, 2004.

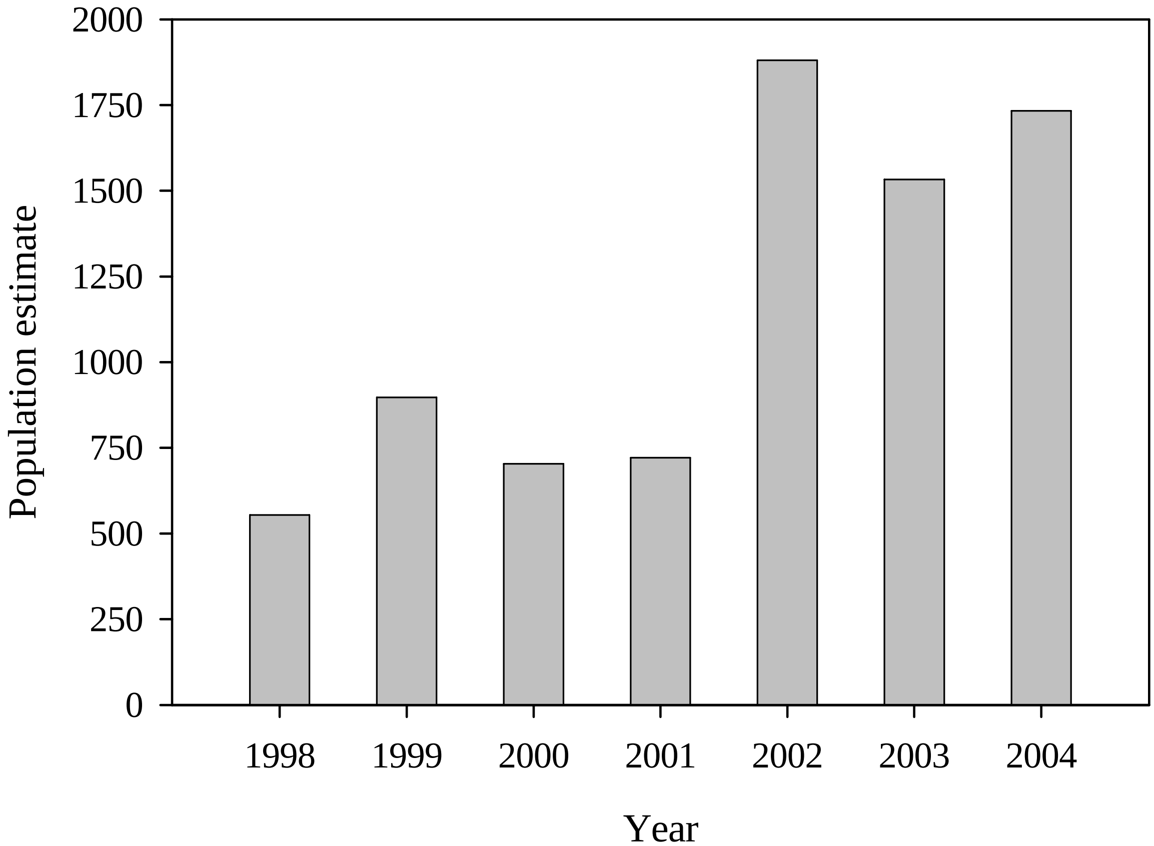

Figure 7. Population estimates for wild fall Chinook salmon in the Ives / Pierce island area below Bonneville Dam, 1998-2004.

To assist in determining stock origins of returning fish we collected biological data from 398 fall Chinook salmon carcasses, including age composition, mean FL, and gender ratio (Table 1). Age 4 was the predominant age class in 2004 and the majority of fish were females (53.3%). Fall Chinook salmon in the study area showed similarities in age class representation and length-at-age with other late-spawning fall Chinook salmon found in the Columbia River basin (Hansen and Johnson 1985). In 2004, fall Chinook salmon lengths-at-age were also similar to those we observed in previous years (van der Naald et al. 2001, 2002, 2003, 2004).

To further help in determining the stock origin of salmon found below Bonneville Dam, we sampled all carcasses for fin marks and other external marks. Seven fall Chinook salmon carcasses had adipose fin marks, and two of these contained coded-wire tags. Both fish were released as subyearlings from upriver bright fall Chinook salmon facilities above the study area. One fish was released from Bonneville Hatchery in Oregon and the other from Klickitat Hatchery in Washington.

Table 1. Age and fork length (cm) of male and female fall Chinook salmon carcasses recovered near Ives and Pierce islands below Bonneville Dam, 2004.

	Number		Percent		Mean fork length		Fork length range	
Age	Male	Female	Male	Female	Male	Female	Male	Female
2	2	0	0.5	0.0	46	--	44-47	--
3	38	17	9.5	4.3	65	74	45-84	63-88
4	84	147	21.1	36.9	84	85	57-110	68-97
5	59	47	14.8	11.8	101	91	79-114	71-104
6	3	1	0.8	0.3	109	89	102-120	89
Overall	186	212	46.7	53.3	85	85	44-120	63-104

Bright fall Chinook salmon found below Bonneville Dam were sampled by WDFW in 1996 and 1997 to characterize genetic traits (WDFW, unpublished data). Analysis of 142 samples showed relatively small genetic differences between the below Bonneville Dam samples and samples taken from other Columbia River late-spawning fall Chinook salmon. This analysis suggests bright Chinook salmon spawning below Bonneville Dam are genetically similar to other bright fall Chinook salmon populations found in the Columbia River, such as stocks found in the Hanford Reach and at Bonneville Hatchery.

Juvenile Fall Chinook Salmon

To ensure that we began sampling as close as possible to the beginning of juvenile emergence, we estimated fry development and emergence timing using temperature unit data. The estimates we chose to represent emergence dates for 2004 brood fall Chinook salmon (Table 2) were based on how closely they matched our juvenile catch data. Temperature sensors in the spawning area below the mouth of Hamilton Creek showed upwelling water to be warmer than the surrounding river water (Geist et al. 2002, PNNL unpublished data). The upwelling water increases the water temperature in redds on average by several degrees C. Using the temperature readings of gauges below Hamilton Creek, we estimated the earliest emergence of Chinook salmon occurred on 6 January 2005 . Although some fall Chinook salmon spawned in the Hamilton Creek area (43%), we found the majority spawned in areas where the warmer upwelling water was not documented. However, the gauge that best helps describe peak emergence for fall Chinook salmon was below Hamilton Creek. We estimated peak emergence occurred 12 March, and the end of emergence occurred 27 May.

We began sampling juvenile salmonids on 13 January 2005. Sampling was completed 28 June, after it appeared that the majority of juvenile fish had migrated from the study area. We

Table 2. Observed spawning dates and estimates of eyeing, hatching, and emergence dates for fall Chinook salmon in the Ives / Pierce island area, 2004-2005. Temperature gauge locations are shown in Figure 3. Dates in bold type indicate those that most closely matched observed emergence dates.

				Estimated emergence by gauge site			
Spawn event	Spawn date	Eyed out	Hatching	G1	T1LB	T2LB	T2MC
Start spawn	10/12	10/29	11/23	03/04	**01/06**	12/09	12/20
Peak spawn	11/16	12/15	02/13	05/01	03/09	03/06	**03/12**
End spawn	12/28	03/07	04/13	**05/27**	04/30	05/21	05/07

captured 48,531 juvenile Chinook salmon in areas below Bonneville Dam, the highest count in seven years of sampling (van der Naald et al. 2004). Favorable flow levels, improved gear, and earlier start times likely contributed to an increase in catch from previous years. We measured 18,922 of the Chinook salmon collected. In 2005, our catch per unit of effort (CPUE) for stick and beach seines were 71.0 and 90.4 (Figure 8). The highest CPUEs occurred in 2004, 78.2 for stick seines and 109.2 for beach seines (van der Naald 2004).

While we caught juvenile Chinook salmon in all sampling sections around Ives and Pierce islands, some areas were more productive. Those that were closest to redds or rearing habitat yielded the highest catches, including sections 5, 6, and 8 (Figure 4; Table 3). Section 8 produced 25% of the juvenile Chinook salmon catch in the area around the islands; sections 5 and 6 yielded 21% and 14% of the catch. Proportional catches in the remaining 10 sections ranged from 0-11%. We recognize this data is of limited usefulness without a measure of relative sampling effort. Future analyses will include catch rate analyses, density estimates, or similar indexes of abundance.

Recently emerged fish (< 40-mm FL) appeared in the catch from 13 January to 17 June (Figure 9, Appendix Table 2). Fish 40-49-mm FL comprised the largest proportion of catch January through May; in June the catch was more evenly distributed and fish up to 79-mm FL were common. The peak catch of juvenile Chinook salmon that were likely wild, native fish (those < 50-mm FL) occurred on 15 April. The peak catch of Chinook salmon in all size categories < 150-mm FL was 18 April (Figure 10).

From 11 February to 2 April, the mean FL of juvenile Chinook salmon increased from 43 to 45 mm, a growth rate of about 0.03 mm/day (Appendix Table 1). During this period daily water temperatures increased from 4.2 to 7.6 ^{o}C (USACE 2005). From 29 April to 4 June, daily water temperatures increased from 11.7 to 15.2 ^{o}C and mean FL increased from 46 to 58 mm, a growth rate of about 0.34 mm/day. It appeared the majority of wild Chinook salmon reared below Bonneville Dam until they reached approximately 70-80 mm FL, since fish >80 mm FL were uncommon in all months (Figure 9). The number of juvenile Chinook salmon

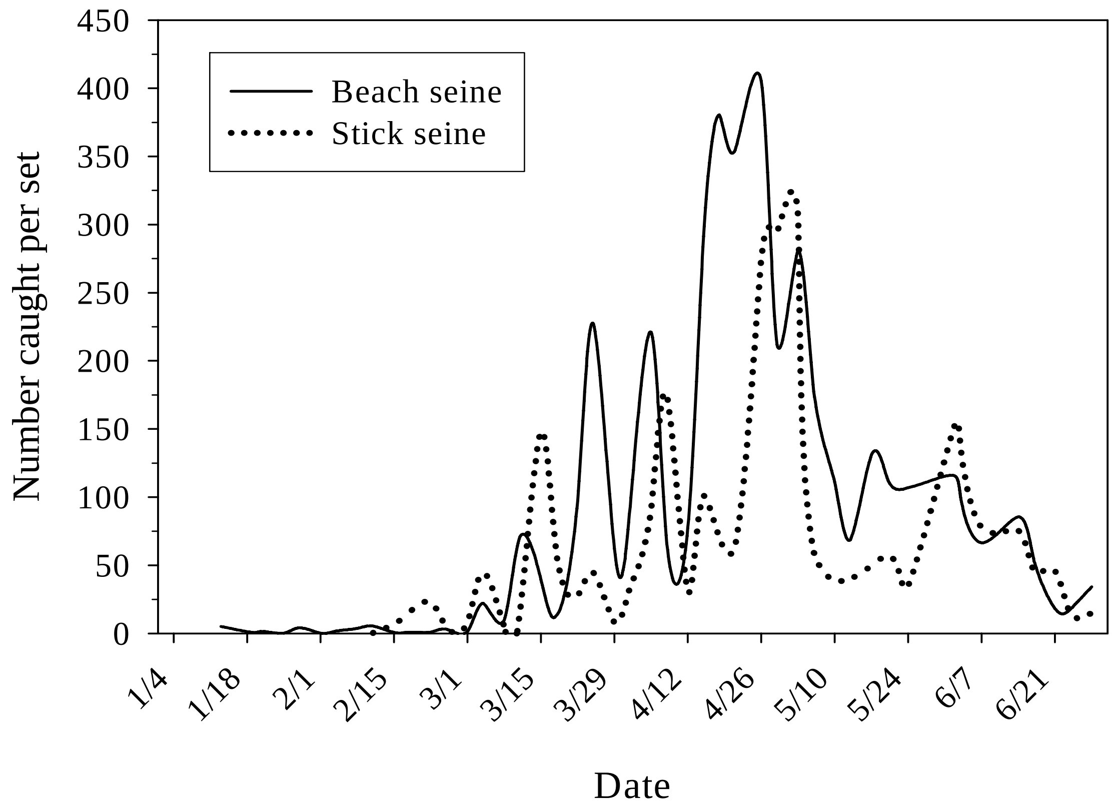

Figure 8. Catch rates of juvenile Chinook salmon captured with beach and stick seines below Bonneville Dam, 2005.

Table 3. Percent catch of juvenile fall Chinook salmon, adipose-marked fall Chinook salmon, and chum salmon by sampling section, 2005.

Section	Fall Chinook salmon	Marked fall Chinook salmon	Chum salmon
1	3	1	0
2	6	1	20
3	7	2	5
4	1	2	0
5	21	4	13
6	14	4	11
7	2	20	0
8	25	6	18
9	0	3	0
10	11	8	30
11	4	37	1
12	1	11	1
13	6	2	1

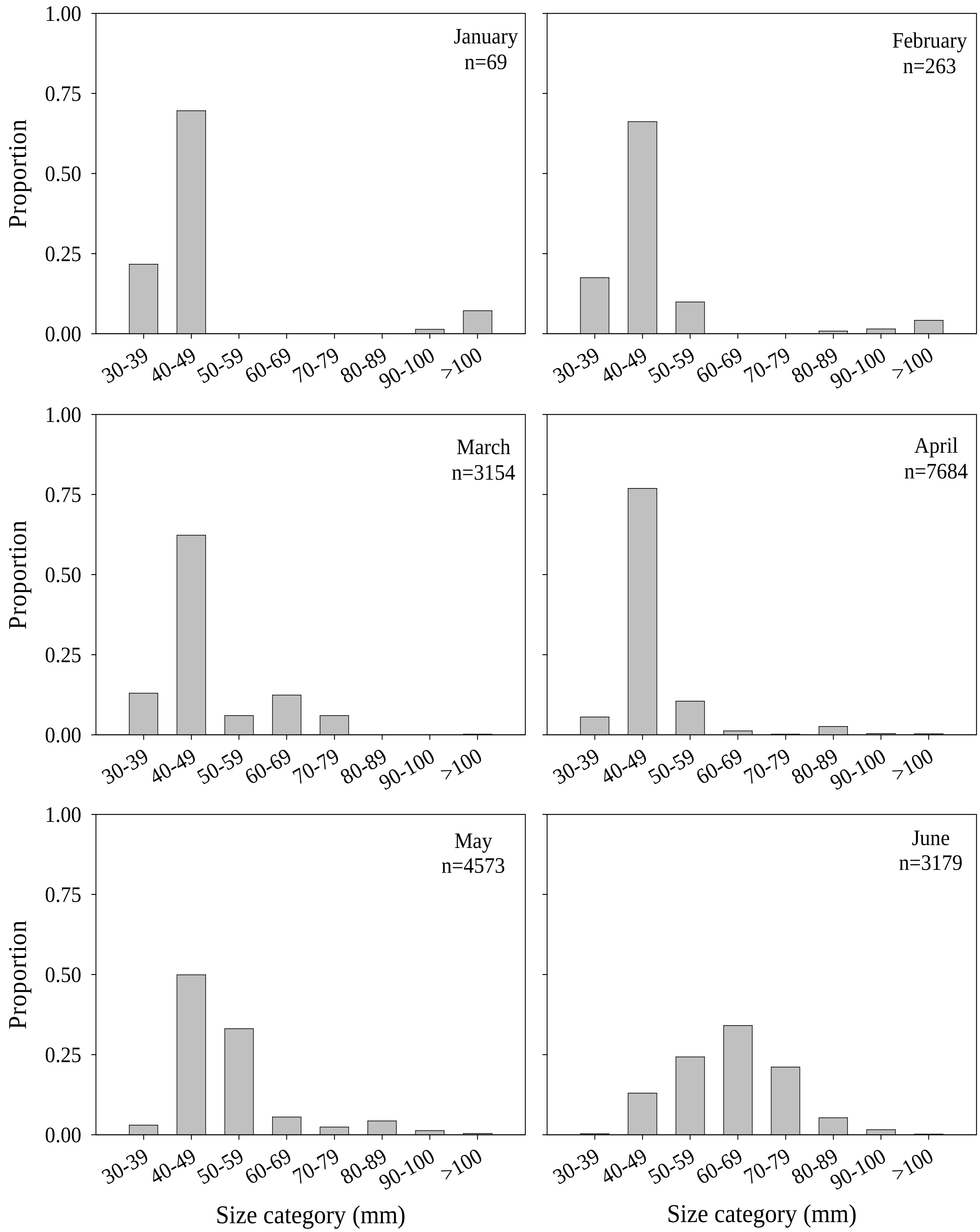

Figure 9. Monthly juvenile fall Chinook salmon catch by size category (mm fork length) below Bonneville Dam, 2005.

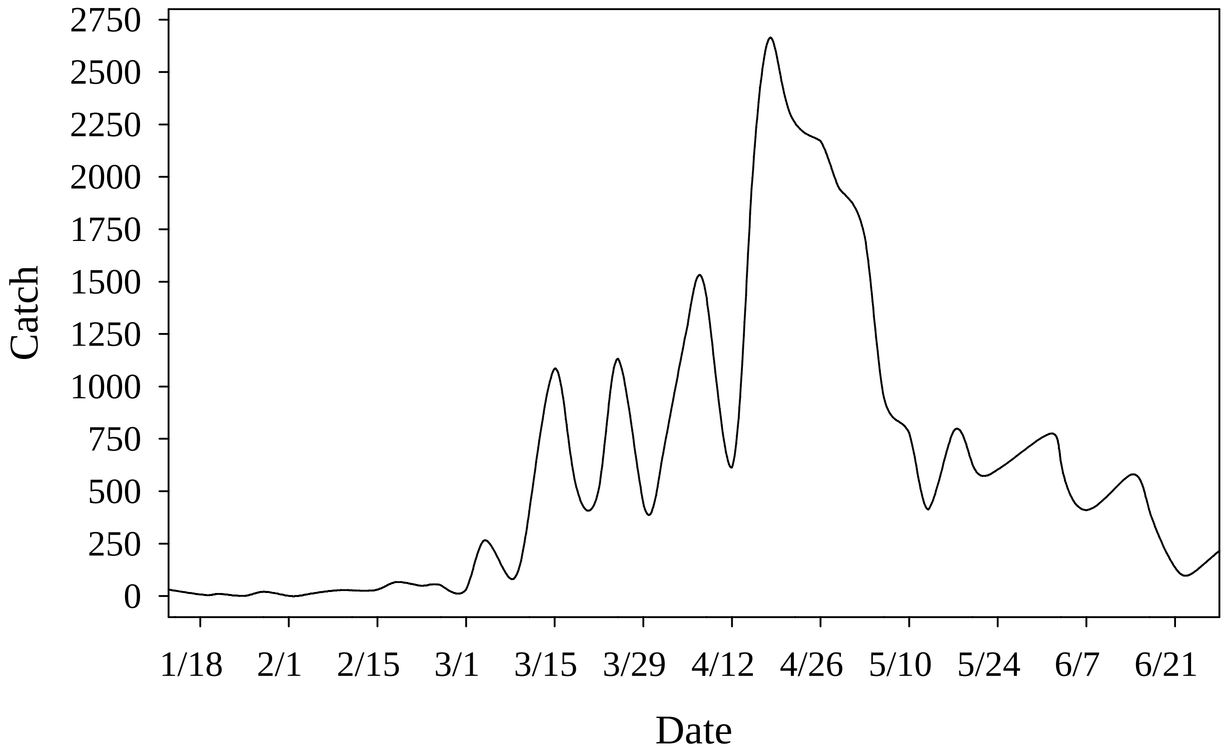

Figure 10. Catches of juvenile Chinook salmon below Bonneville Dam by sample date, 2005.

we caught declined steadily in May and June, suggesting that outmigration was occurring during that time (Appendix Table 1).

We examined juvenile Chinook salmon for fin marks to determine the stock composition of fish rearing in areas below Bonneville Dam. Identifying hatchery released juveniles aided in determining which stocks, besides the native Chinook salmon, used areas below the dam. When hatchery fish with fin clips appeared in our catch, they were larger than the native wild Chinook salmon. This was especially noticeable during March and May, when Spring Creek National Fish Hatchery (SCNFH) released early-spawning stock fall Chinook salmon just above Bonneville Dam. Since the unmarked component of the SCNFH releases were the same size as the marked component, wild fish could be easily differentiated from hatchery-released fish.

In 2005, SCNFH fall Chinook salmon were observed in our catch in early March, mid-March, and early May. Soon after being released from the hatchery, they occupied the area for a week or more before moving downriver. Besides fish from SCNFH, yearling fish from upriver spring and fall Chinook salmon facilities were occasionally caught around the islands. Wild upriver subyearling fall Chinook salmon were not present in areas below Bonneville Dam when juvenile sampling was in progress, since they outmigrate later in the summer (Fish Passage Center 2005).

In 2005, we captured 1,548 juvenile fall Chinook salmon with fin marks. The majority of these were from SCNFH where, beginning this year, most were adipose marked. We do not know how many unmarked hatchery juvenile salmon we caught in this year's sampling that were not from SCNFH. Hatchery releases in the Columbia River basin have from zero to 90 unmarked fish associated with each marked fish released (Fish Passage Center 2005).

The distribution of the fin-marked fish among sampling sections was different from the other juvenile fall Chinook salmon we observed (Table 3). Sections 7, 11, and 12 produced 68% of the catch; the remaining 10 sections varied from 1-8% each.

We tagged and marked 33,323 wild juvenile fall Chinook salmon with coded-wire tags and adipose fin clips in April and May 2005 (Appendix Table 2). The overnight tag retention was 93.6% and the mortality rate of tagged fish was 2.0%; we released 32,642 live fish. The number of fish tagged has varied among years (Figure 11), but has increased every year since 2002 with improved catch rates and refined tagging procedures. From 2001-2005, we have marked and released 81,147 fall Chinook salmon. Through the 2004-2005 run year, none of these have been recovered as adults or reported to PSMFC's Regional Mark Information System (PSMFC 2005). Because the early releases (2001-2003) were small and the average age of adult fish is four years, the probability of recoveries was quite low. With the passage of time and increased releases of marked and tagged fish, we expect to collect data in future years to determine juvenile to adult survival rates of the Ives and Pierce island spawning population.

Adult Chum Salmon

Based on our spawning ground surveys, the initiation of spawning below Bonneville Dam for chum salmon was 9 November 2004 (Figure 12). At peak spawning, on 3 December we observed 148 redds and 99 live fish. Spawning had ended by 28 December, our last survey day.

During the previous six years of spawning ground surveys, we observed the onset of chum salmon spawning during the first week of November (van der Naald et al. 2000, 2001, 2002, 2003, 2004). The earliest peak spawning date for chum salmon was 16 November (1998) and the latest occurred 6 December (2002). In 2004, timing of chum salmon spawning below Bonneville Dam was similar to that of chum salmon spawning in nearby Hardy and Hamilton creeks (Fish Passage Center 2005b). From our field surveys, WDFW estimated 336 chum salmon adults returned to spawn in 2004, the lowest count since 2000 (Figure 13; van der Naald et al. 2001, 2002, 2003, 2004).

We observed the majority of chum salmon redds below the mouth of Hamilton Creek (Section 2, Figure 2; Figure 14). This area was the site most frequently used by chum salmon in past years (van der Naald et al. 2002, 2003, 2004). We also observed chum salmon spawning in the channel between Ives and Pierce islands, below Woodward Creek near Beacon Rock and on the Oregon side of the Columbia River below McCord Creek.

We collected 119 biological samples from chum salmon carcasses to determine age composition, size distribution, and gender ratio of fish returning to the study area (Table 4).

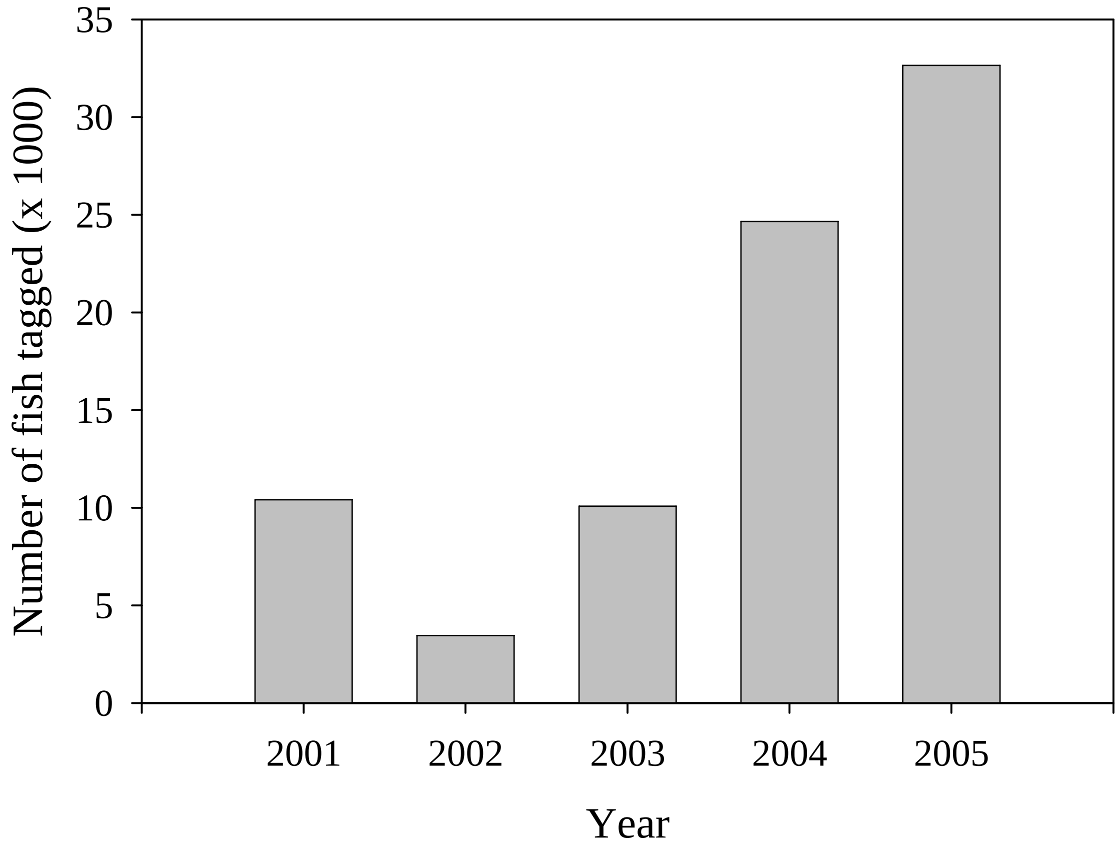

Figure 11. Number of wild fall Chinook salmon fin-marked, tagged and released below Bonneville Dam, 2001 – 2005.

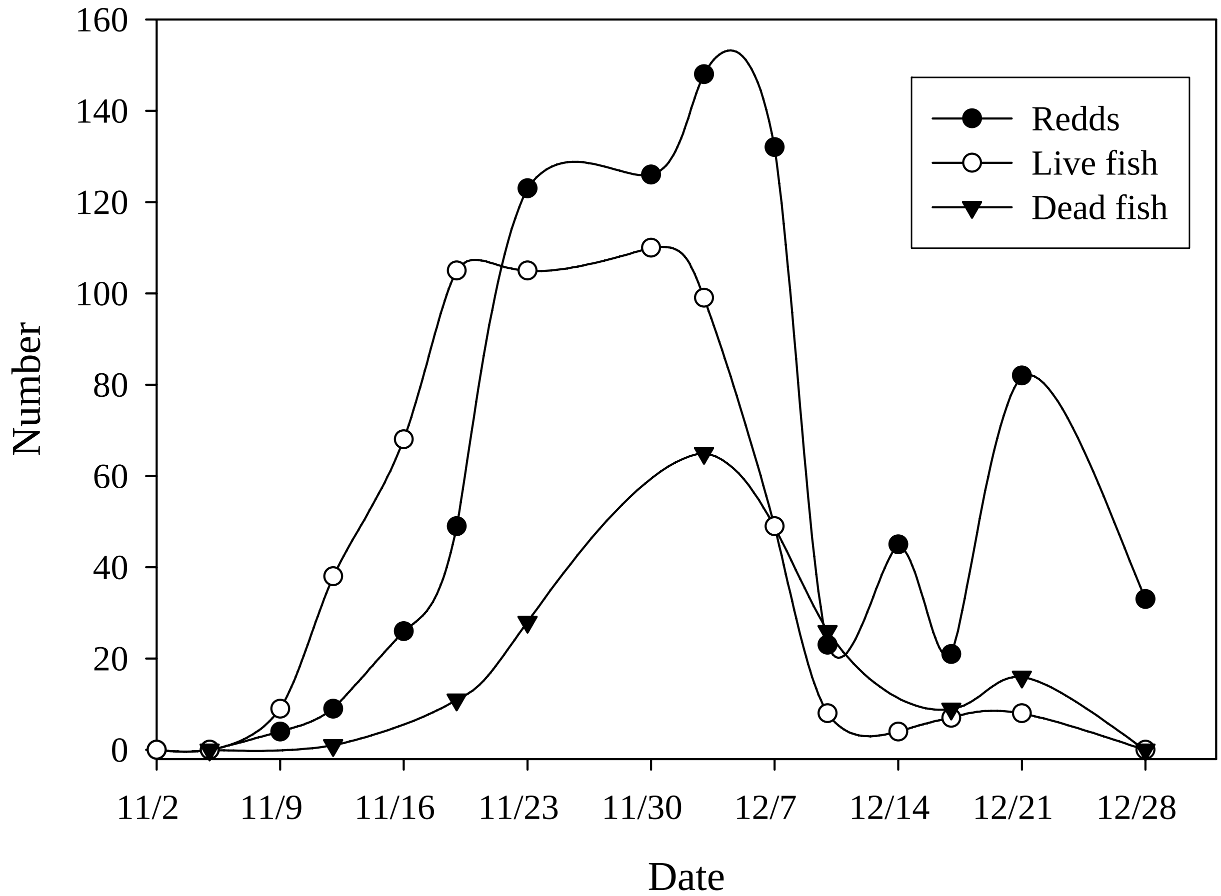

Figure 12. Number of live and dead chum salmon and chum salmon redds observed below Bonneville Dam by date, 2004.

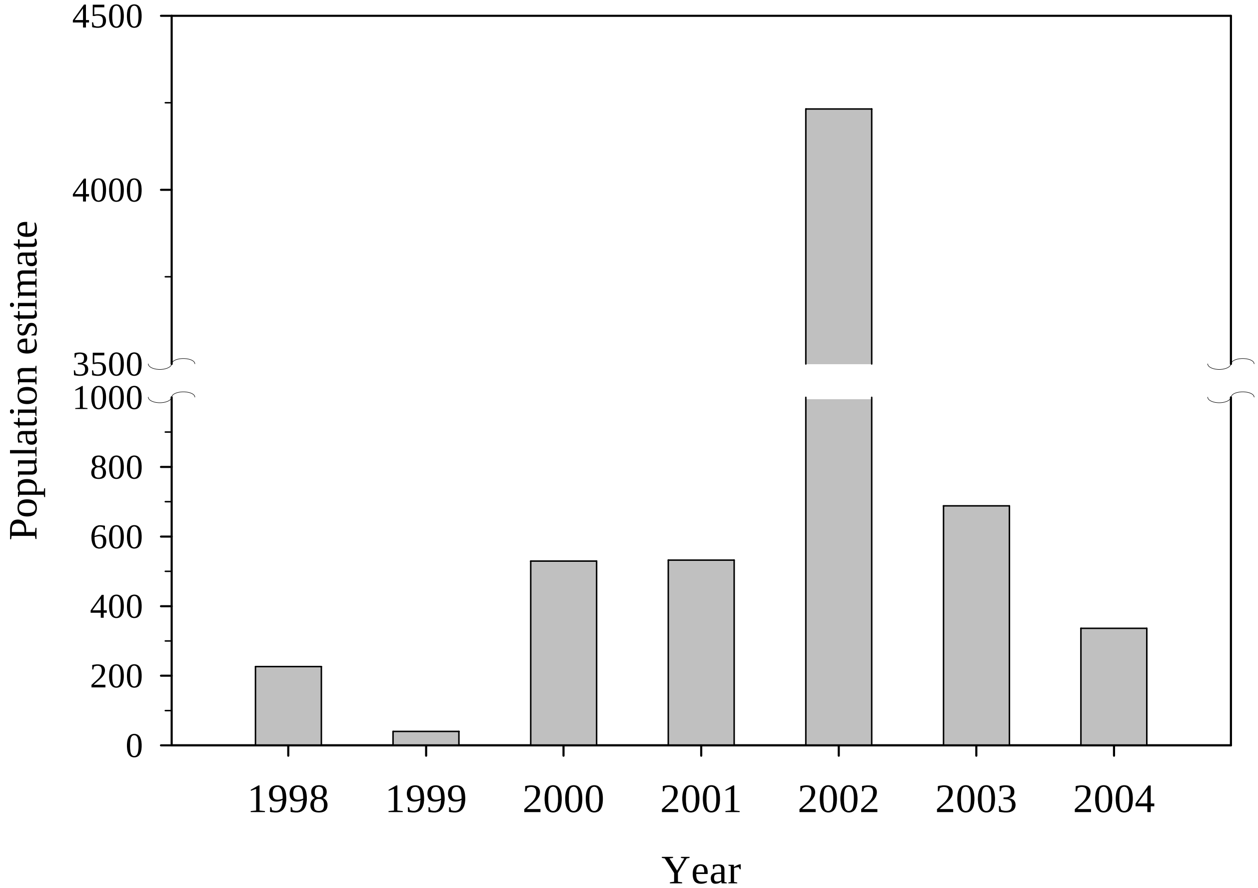

Figure 13. Population estimates for chum salmon in the Ives / Pierce island area below Bonneville Dam, 1998-2004.

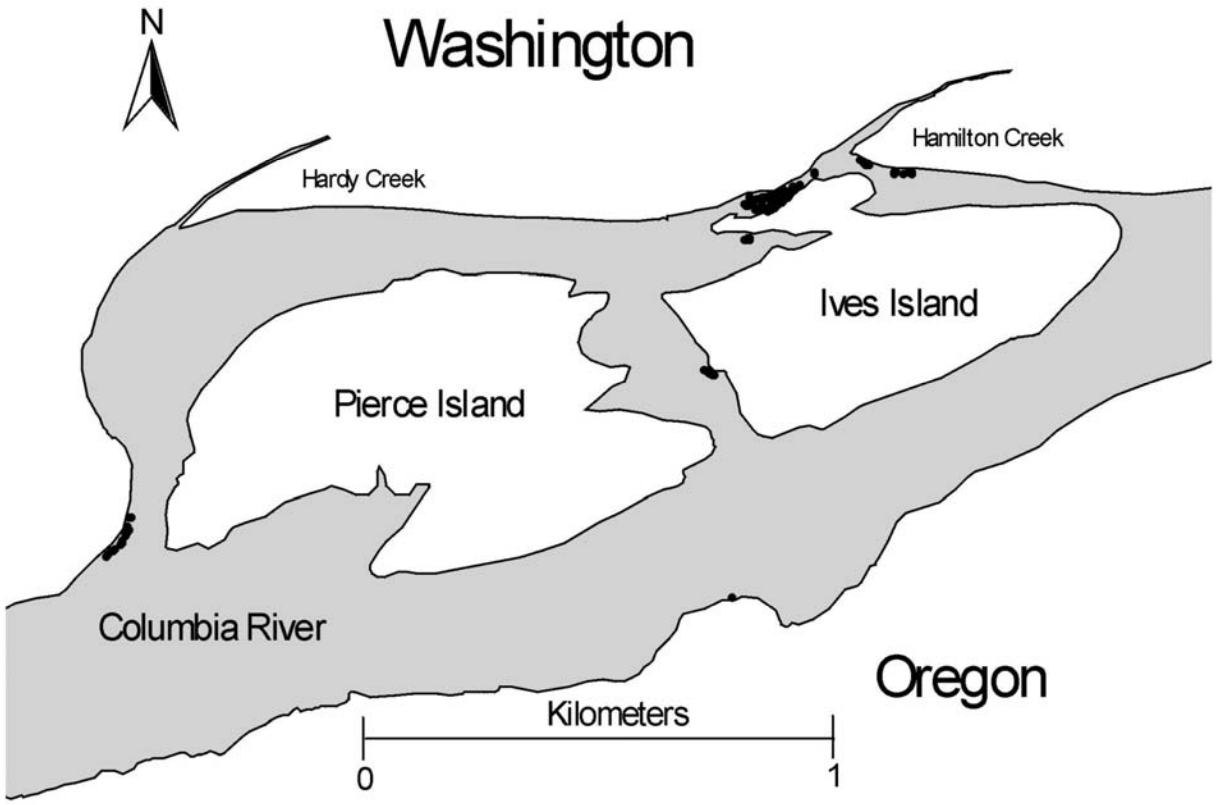

Figure 14. Locations (black circles) of chum salmon redds below Bonneville Dam, 2004.

Table 4. Age and fork length (cm) of male and female chum salmon carcasses recovered near Ives and Pierce islands below Bonneville Dam, 2004.

	Number		Percent		Mean fork length		Fork length range	
Age	Male	Female	Male	Female	Male	Female	Male	Female
3	11	25	9.2	21.0	74	68	68-85	62-78
4	34	30	28.6	25.2	79	71	70-87	64-77
5	12	7	10.1	5.9	80	75	69-89	70-87
Overall	57	62	47.9	52.1	79	70	68-89	62-87

Four-year-old fish were the predominant age class in 2004, composing 53.8 percent of the population. We collected more females (62) than males (57), and the mean fork length for males was generally larger (79 cm) than for females (70 cm).

Small (In press) analyzed genotypes of chum salmon spawning near Ives Island and concluded these fish have close genetic relationships with populations from nearby Hardy and Hamilton creeks. These fish comprise the “gorge” population and are genetically distinct from chum salmon found lower in the Columbia River basin (“cascade” and “coastal” populations).

Juvenile Chum Salmon

As with Chinook salmon, we estimated chum salmon fry development and emergence timing using temperature unit data. The estimates we chose to represent emergence dates of chum salmon (Table 5) were based on how closely they matched the seine catch data. The majority of chum salmon used the shallow margins of the Hamilton Creek channel because they prefer areas with a groundwater source (Geist et al. 2002). Using the temperature readings from gauges below Hamilton Creek, we estimated earliest emergence of chum salmon occurred 4 February and continued through 2 May. We estimated peak emergence occurred on about 21 March.

In 2005, we caught the first juvenile chum salmon on 15 February and the last one on 24 May. The peak catch occurred on 25 March (Figure 15). We captured 1,909 juvenile chum salmon, the third highest total in seven years of sampling (van der Naald et al 2004). As with fall Chinook salmon, favorable flow levels, improved gear, and earlier start times likely contributed to the relatively high catch. In 2005, catch rates for stick and beach seines were 3.8 and 5.5 fish per set (Figure 16), compared to 5.9 and 16.3 in 2004 (van der Naald et al. 2004). The mean FL of juvenile chum salmon was 43.6 mm. Recently emerged fish (< 40-mm FL) were present in the catch from 15 February to 29 April, although fish 40-49-mm FL dominated the catch March through April (Figure 17, Appendix Table 3). Larger fish (> 50-mm FL) were observed only in April and May.

While we caught juvenile chum salmon in most of the sampling sections, we found some areas more productive than others. Areas that were closest to redds or good rearing habitat produced the highest catches; these included sections 2, 5, 8 and 10 (Figure 4, Table 3). Section 10 produced 30% of the catch in the area around the islands. Sections 2, 5, and 8 yielded an additional 61% (combined). Again, future analyses will include catch rate analyses, density estimates, or similar indexes of abundance, improving the utility of this data.

Mean FL of juvenile chum salmon appeared to increase with increasing water temperature. From 11 March to 15 April mean FL increased from 41 to 46 mm (Appendix Table 3), a growth rate of approximately 0.13 mm/day. Also during this period, daily water temperatures increased from 6.1 to 9.4 °C (USACE 2005). It appeared the majority of chum salmon reared below Bonneville Dam until they attained a size of 45-50 mm FL, then began migrating out of the area (Figure 17). Catch rates declined in late March, further suggesting that outmigration was occurring (Appendix Table 3). By early June, we observed no juvenile chum salmon.

Table 5. Observed spawning dates and estimates of eyeing, hatching, and emergence dates for chum salmon in the Ives / Pierce island area, 2004-2005. Gauge locations are shown in Figure 3. Dates in bold type indicate those that most closely matched observed emergence dates.

				Estimated emergence by gauge site			
Spawn event	Spawn date	Eyed out	Hatching	G1	T1LB	T2LB	T2MC
Start spawn	11/9	12/27	02/22	04/03	**02/04**	01/19	01/29
Peak spawn	12/03	02/28	04/03	04/29	03/13	**03/21**	03/19
End spawn	12/28	03/31	04/24	05/14	04/11	**05/02**	04/21

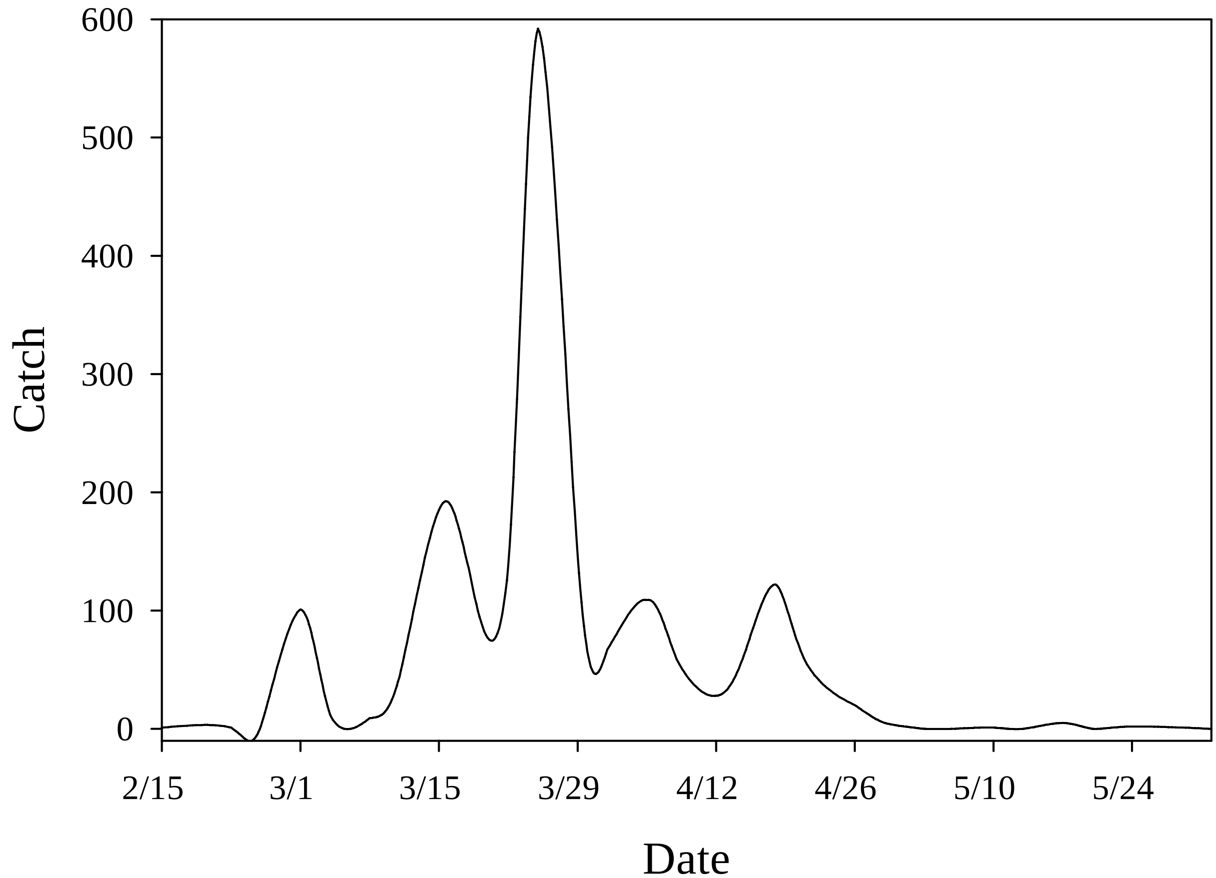

Figure 15. Catch of juvenile chum salmon below Bonneville Dam by sample date, 2005.

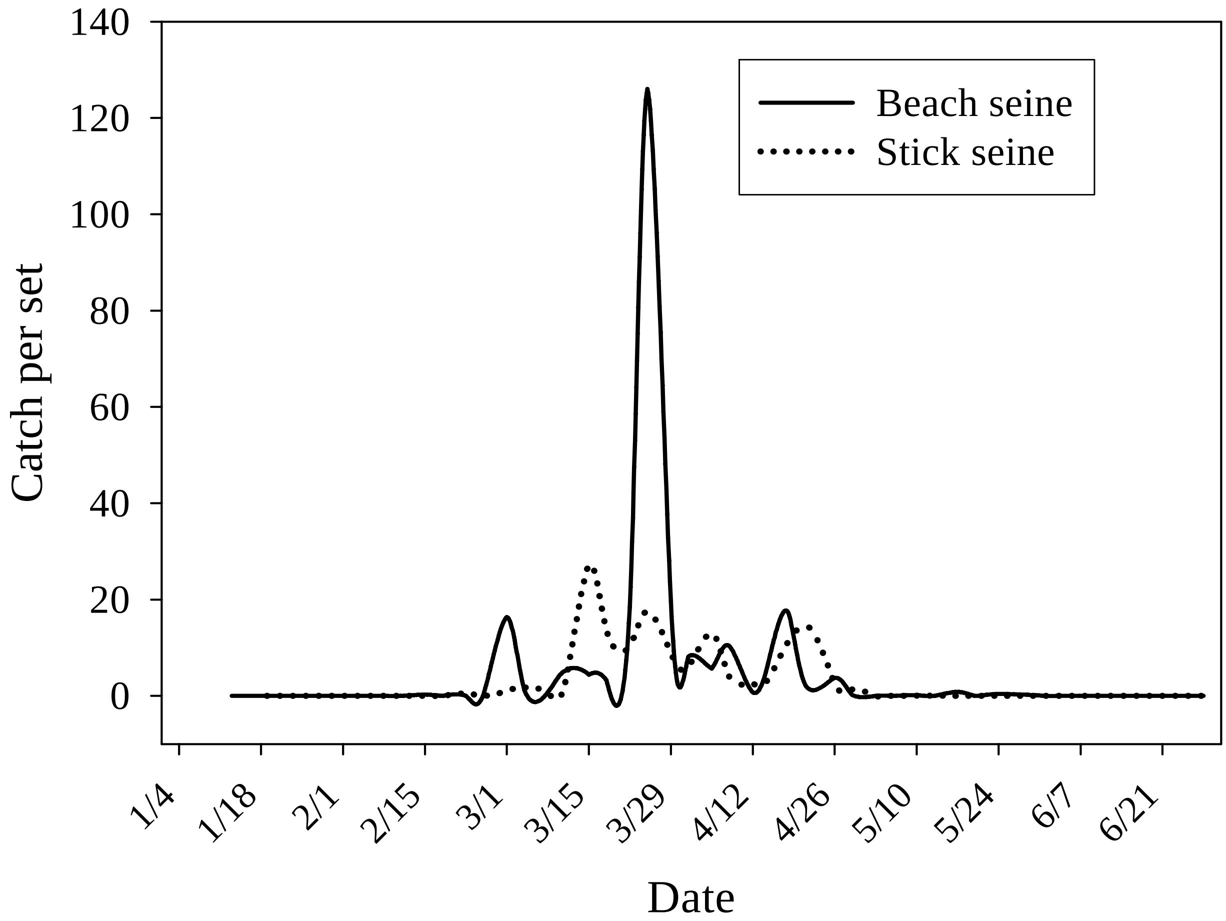

Figure 16. Catch rates of juvenile chum salmon captured with beach and stick seines below Bonneville Dam, 2005.

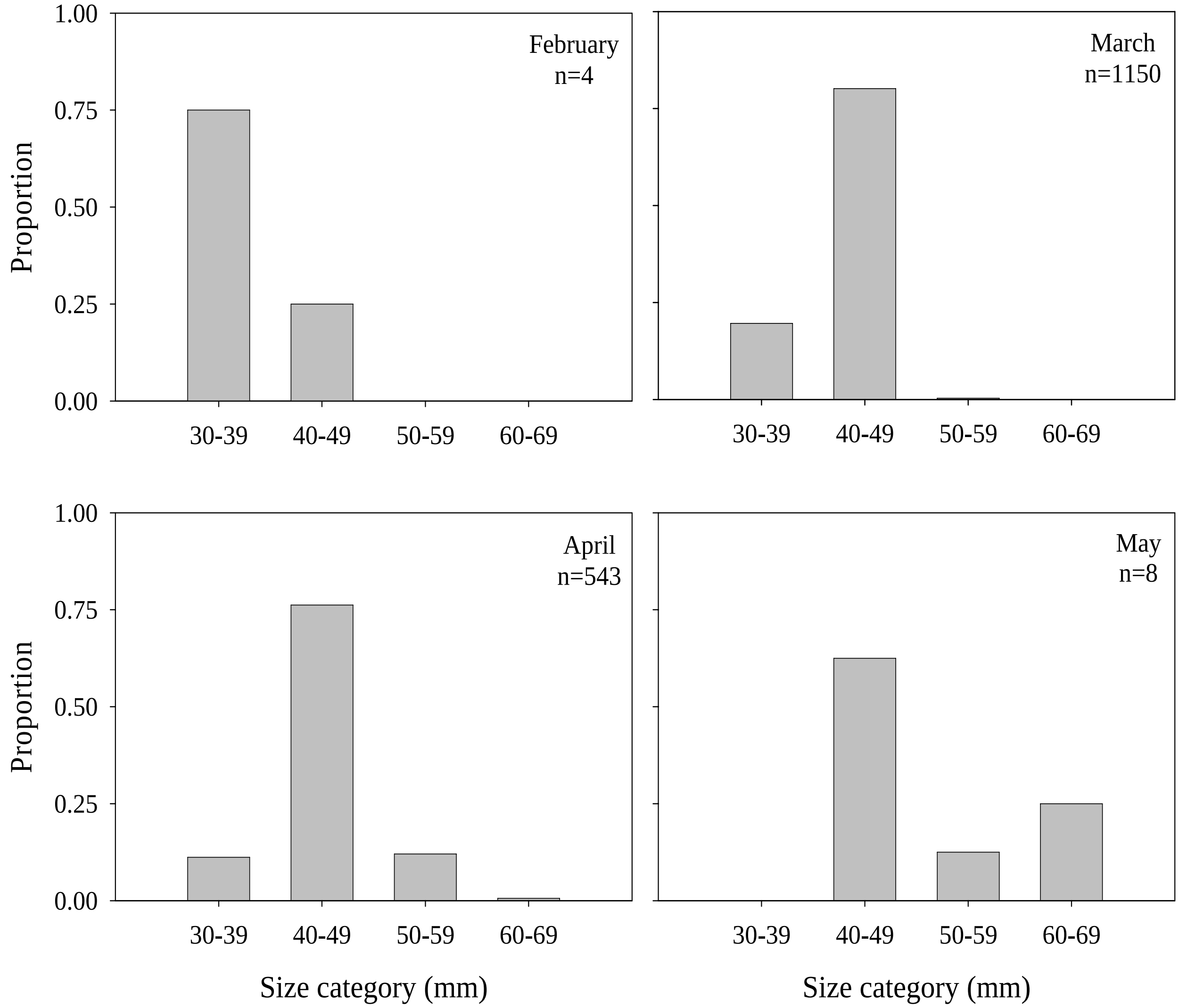

Figure 17. Monthly juvenile chum salmon catch by size category (mm fork length) below Bonneville Dam, 2005.

We were not able to determine the origin of the juvenile chum salmon we collected. Fish that reared in the study area were likely a mix of those from the mainstem Columbia River and nearby Hamilton and Hardy creeks. Since none of the fish were marked, it was not possible to differentiate among these groups.

PLANS FOR 2005-2006

Activities in 2005-2006 will remain largely unchanged from 2004-2005. We plan to continue making field observations of fall Chinook and chum salmon below Bonneville Dam near Ives and Pierce islands, and to document the time and location of spawning. By mutual agreement, WDFW will assume the responsibility for estimating the population sizes of spawning fall Chinook salmon, but we will continue to provide estimates for chum salmon. We will use biological data and CWT recoveries to describe stocks and determine stock origins for both species, where possible.

We will continue to estimate emergence timing, document outmigration, and determine size at migration for juvenile fall Chinook and chum salmon below Bonneville Dam. We will again mark at least 25,000 juvenile fall Chinook salmon with CWTs to determine the juvenile to adult survival rate, and continue to provide survey data for use in making Columbia River management decisions.

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APPENDIX

Detailed Fork Length Distributions and Fall Chinook Salmon Tagging Data

Appendix Table 1. Fork length (FL; mm) distribution by sample date for juvenile fall Chinook salmon captured below Bonneville Dam, 2005.

				Number of fish by size class								Mean FL
Week	Date	Total	FL range	30-39	40-49	50-59	60-69	70-79	80-89	90-100	>100	(fish < 150)
3	13-Jan	31	37-114	4	25	0	0	0	0	1	1	45
4	19-Jan	5	40-43	0	5	0	0	0	0	0	0	42
4	21-Jan	11	34-111	9	1	0	0	0	0	0	1	44
5	25-Jan	1	104	0	0	0	0	0	0	0	1	104
5	28-Jan	21	38-111	2	17	0	0	0	0	0	2	50
6	1-Feb	1	41	0	1	0	0	0	0	0	0	41
6	4-Feb	9	32-46	7	2	0	0	0	0	0	0	39
7	8-Feb	26	37-116	3	5	1	0	0	2	4	11	82
7	11-Feb	28	37-49	5	23	0	0	0	0	0	0	43
8	15-Feb	31	34-54	10	18	3	0	0	0	0	0	43
8	18-Feb	67	37-53	10	49	8	0	0	0	0	0	44
9	22-Feb	49	39-56	5	35	9	0	0	0	0	0	45
9	25-Feb	52	37-56	6	41	5	0	0	0	0	0	44
10	1-Mar	32	38-59	4	22	6	0	0	0	0	0	45
10	4-Mar	267	34-119	33	100	28	94	11	0	0	1	53
11	8-Mar	84	35-70	10	28	23	22	1	0	0	0	52
11	11-Mar	406 [1]	37-76	44	154	31	65	21	0	0	0	50
12	15-Mar	1,085 [1]	37-135	59	252	30	78	25	1	0	1	49
12	18-Mar	581 [1]	37-75	48	265	32	26	8	0	0	0	46
13	22-Mar	515	36-80	57	365	11	43	38	1	0	0	47
13	25-Mar	1,132 [1]	34-137	85	519	6	36	73	1	0	3	47
14	29-Mar	444 [1]	35-82	70	260	22	28	12	1	0	0	45
14	1-Apr	661	37-136	80	515	22	16	24	1	0	3	45
15	5-Apr	1,293 [1]	38-158	38	291	6	1	1	0	0	5	44
15	8-Apr	1,423 [1]	37-77	35	477	50	6	9	0	0	0	45
16	12-Apr	614	35-174	15	389	88	20	44	50	3	5	53
16	15-Apr	1,886 [1]	36-147	40	1,258	198	13	11	18	3	4	47
17	18-Apr	2,663 [1]	37-134	37	751	76	5	46	40	6	3	48
17	21-Apr	2,317 [1]	35-95	43	788	245	25	39	55	11	0	50
18	26-Apr	2,171 [1]	35-128	76	728	70	6	3	4	0	1	45
18	29-Apr	1,942 [1]	35-138	78	712	48	1	5	33	8	2	46
19	3-May	1,712 [1]	36-188	36	551	177	28	24	61	24	4	52
19	6-May	947 [1]	34-145	32	522	108	13	39	81	25	8	54
20	10-May	778 [1]	35-142	24	397	224	26	14	26	6	2	51
20	13-May	413	38-95	6	253	111	18	5	16	4	0	51
21	17-May	786 [1]	35-83	15	184	340	31	4	3	0	0	52
21	20-May	629 [1]	33-153	18	246	340	21	1	0	0	3	51
22	24-May	604 [1]	38-90	8	131	215	116	22	8	2	0	56
23	1-Jun	772 [1]	37-85	7	205	227	207	35	3	0	0	55
23	3-Jun	636	39-92	3	137	211	222	56	6	1	0	58
24	7-Jun	410	42-101	0	38	117	142	87	18	7	1	64
25	14-Jun	579	44-114	0	16	125	217	154	36	26	5	68
25	17-Jun	403	39-99	1	10	52	148	152	32	8	0	69
26	21-Jun	137	44-95	0	8	22	49	44	11	3	0	67
26	24-Jun	114	52-95	0	0	13	52	43	5	1	0	69
27	28-Jun	216	56-93	0	0	5	48	99	58	6	0	75
		28,984 [1]		1,063	10,794	3,305	1,823	1,150	571	149	67	

[1] Includes fish that were not measured.

Appendix Table 2. Juvenile fall Chinook salmon tagged and released below Bonneville Dam, 2005.

Date	Number sampled	Mean fork length	% untaggable (<47 or >65mm)	Tag code	Number tagged	Mortalities	% mortality	Number released
22-Apr	2,489	50.7	28.8	094154	1,773	63	3.6	1,710
27-Apr	2,721	47.9	25.2	094154	2,036	114	5.6	1,922
29-Apr	3,310	49.3	29.8	094154	2,323	18	0.8	2,305
3-May	4,614	49.9	42.2	094154	2,664	31	1.2	2,633
4-May	2,651	49.7	46.5	094154	1,417	16	1.1	1,401
5-May	3,003	49.4	60.6	094154	804	10	1.2	794
				094152	363	4	1.1	359
6-May	3,555	50.6	48.1	094152	981	18	1.8	963
				094154	135	3	2.2	132
				094024	728	15	2.1	713
10-May	3,525	50.3	34.6	094152	844	5	0.6	839
				094024	1,462	9	0.6	1,453
11-May	2,046	50.9	21.4	094152	749	5	0.7	744
				094024	859	6	0.7	853
12-May	2,465	51.0	19.4	094152	881	8	0.9	873
				094024	1,106	11	1.0	1,095
13-May	1,959	52.4	18.7	094152	616	8	1.3	608
				094024	977	13	1.3	964
17-May	3,028	52.0	13.9	094152	1,668	16	1.0	1,652
				094024	893	9	1.0	884
18-May	2,114	53.2	17.8	094152	1,174	32	2.7	1,142
				094024	563	16	2.8	547
19-May	2,202	52.5	24.9	094152	663	6	0.9	657
				094024	991	8	0.8	983
20-May	1,855	53.9	21.7	094152	129	5	3.9	124
				094024	1,352	47	3.5	1,305
24-May	1,213	55.3	24.5	094152	533	4	0.8	529
				094024	381	3	0.8	378
25-May	2,339	51.9	23.8	094152	866	7	0.8	859
				094024	916	8	0.9	908
27-May	3,442	54.3	28.1	094152	1,192	78	6.5	1,114
				094024	1,284	85	6.6	1,199
Totals	48,531	51.4	31.3		33,323	681	2.0	32,642

Appendix Table 3. Fork length (FL; mm) distribution by sample date for juvenile Chum salmon captured below Bonneville Dam, 2005.

				Number of fish by size class				
Week	Date	Number	FL range	30-39	40-49	50-59	60-69	Mean FL
8	15-Feb	1	37	1	0	0	0	37
9	22-Feb	1	41	0	1	0	0	41
9	25-Feb	2	39	2	0	0	0	39
10	1-Mar	101	37-47	25	76	0	0	41
10	4-Mar	12	36-44	6	6	0	0	40
11	8-Mar	9	37-49	1	8	0	0	42
11	11-Mar	44	37-46	14	30	0	0	41
12	15-Mar	185	37-50	45	139	1	0	42
12	18-Mar	136	39-49	17	119	0	0	42
13	22-Mar	138	38-47	18	120	0	0	42
13	25-Mar	592[1]	36-50	49	329	1	0	42
14	29-Mar	146	36-50	50	94	2	0	41
14	1-Apr	67	38-52	6	58	3	0	44
15	5-Apr	109	39-59	8	88	13	0	44
15	8-Apr	59	36-57	12	40	7	0	43
16	12-Apr	28	39-53	1	24	3	0	44
16	15-Apr	67	37-58	8	42	17	0	46
17	18-Apr	122	37-62	12	95	13	2	44
17	21-Apr	57	38-55	8	43	6	0	44
18	26-Apr	20	39-60	2	15	2	1	45
18	29-Apr	5	36-43	3	2	0	0	39
19	3-May	0	-	0	0	0	0	-
19	6-May	0	-	0	0	0	0	-
20	10-May	1	53	0	0	1	0	53
20	13-May	0	-	0	0	0	0	-
21	17-May	5	43-49	0	5	0	0	46
21	20-May	0	-	0	0	0	0	-
22	24-May	2	62-65	0	0	0	2	64
23	1-Jun	0	-	0	0	0	0	-
23	3-Jun	0	-	0	0	0	0	-
24	7-Jun	0	-	0	0	0	0	-
25	14-Jun	0	-	0	0	0	0	-
		1,909[1]		288	1,334	69	5	

[1] Includes fish that were not measured.