EVALUATION OF FALL CHINOOK AND CHUM SALMON SPAWNING BELOW BONNEVILLE DAM

Annual Report 2003-2004

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EVALUATION OF FALL CHINOOK AND CHUM SALMON SPAWNING BELOW BONNEVILLE DAM

ABSTRACT

In 2003 a total of 253 adult fall chinook and 113 chum were sampled for biological data in the Ives and Pierce islands area below Bonneville Dam. Vital statistics were developed from 221 fall chinook and 109 chum samples. The peak redd count for fall chinook was 190. The peak redd count for chum was 262. Peak spawning time for fall chinook was set at approximately 24 November. Peak spawning time for chum occurred approximately 24 November. There were estimated to be a total of 1,533 fall chinook spawning below Bonneville Dam in 2003. The study area's 2003 chum population was estimated to be 688 spawning fish.

Temperature unit data suggests that below Bonneville Dam 2003 brood bright stock, fall chinook emergence began on January 6, 2004 and ended 28 April 2004, with peak emergence occurring 13 April. 2003 brood juvenile chum emergence below Bonneville Dam began 22 February and continued through 15 April 2004. Peak chum emergence took place 25 March. A total of 25,433 juvenile chinook and 4,864 juvenile chum were sampled between the dates of 20 January and 28 June 2004 below Bonneville Dam.

Juvenile chum migrated from the study area in the 40-55 mm fork length range. Migration of chum occurred during the months of March, April and May. Sampling results suggest fall chinook migration from rearing areas took place during the month of June 2004 when juvenile fall chinook were in the 65 to 80 mm fork length size range.

Adult and juvenile sampling below Bonneville Dam provided information to assist in determining the stock of fall chinook and chum spawning and rearing below Bonneville Dam. Based on observed spawning times, adult age and sex composition, juvenile emergence timing, juvenile migration timing and juvenile size at the time of migration, it appears that in 2003 all of the fall chinook using the area below Bonneville Dam were of a late-spawning, bright stock. Observed spawning times, adult age and sex composition, GSI and DNA analysis, juvenile emergence timing, juvenile migration timing and juvenile size at the time of migration suggests chum spawning and rearing below Bonneville dam are similar to stocks of chum found in Hamilton and Hardy creek and are part of the Lower Columbia River Chum ESU.

INTRODUCTION

This report describes work conducted by the Oregon Department of Fish and Wildlife (ODFW) and the Pacific States Marine Fisheries Commission (PSMFC) from 1 October 2003 to 30 September 2004. The work is part of studies to evaluate spawning of fall chinook salmon (Oncorhynchus tshawytscha) and chum salmon (O. keta) below the four lowermost Columbia River dams under the Bonneville Power Administration's Project 1999-003-01. The purpose of this portion of the project is twofold:

1) Search for evidence of fall chinook and chum salmon spawning in the mainstem Columbia River below Bonneville Dam (river mile (RM) 145), (Figure 1). Collect biological data to profile the stock and determine possible stock origin.

2) Juvenile fall chinook and chum populations rearing below Bonneville Dam (Ives and Pierce islands) will be sampled to determine emergence timing, timing and size of emigration from rearing areas and rearing distribution. Juvenile fall chinook will be coded-wire tagged for the purpose of juvenile to adult survival rates.

Specific tasks conducted by ODFW and PSMFC (WDFW) during this period were:

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

2) Collection of biological data to profile the fall chinook and chum salmon in areas described in Task 1.

3) Profile fall chinook and chum in areas below Bonneville Dam using data collected in the above task.

4) Collection of data to determine stock origin of fall chinook found in areas described in Task 1.

5) Determination of possible stock origins of fall chinook found in areas described in Task 1 using tag rates based on coded-wire tag recoveries.

6) Determination of emergence timing and hatching rate of juvenile fall chinook and chum in the mainstem Columbia River, below Bonneville Dam.

7) Determination of migration time and size for juvenile fall chinook and chum rearing in the area described in Task 6.

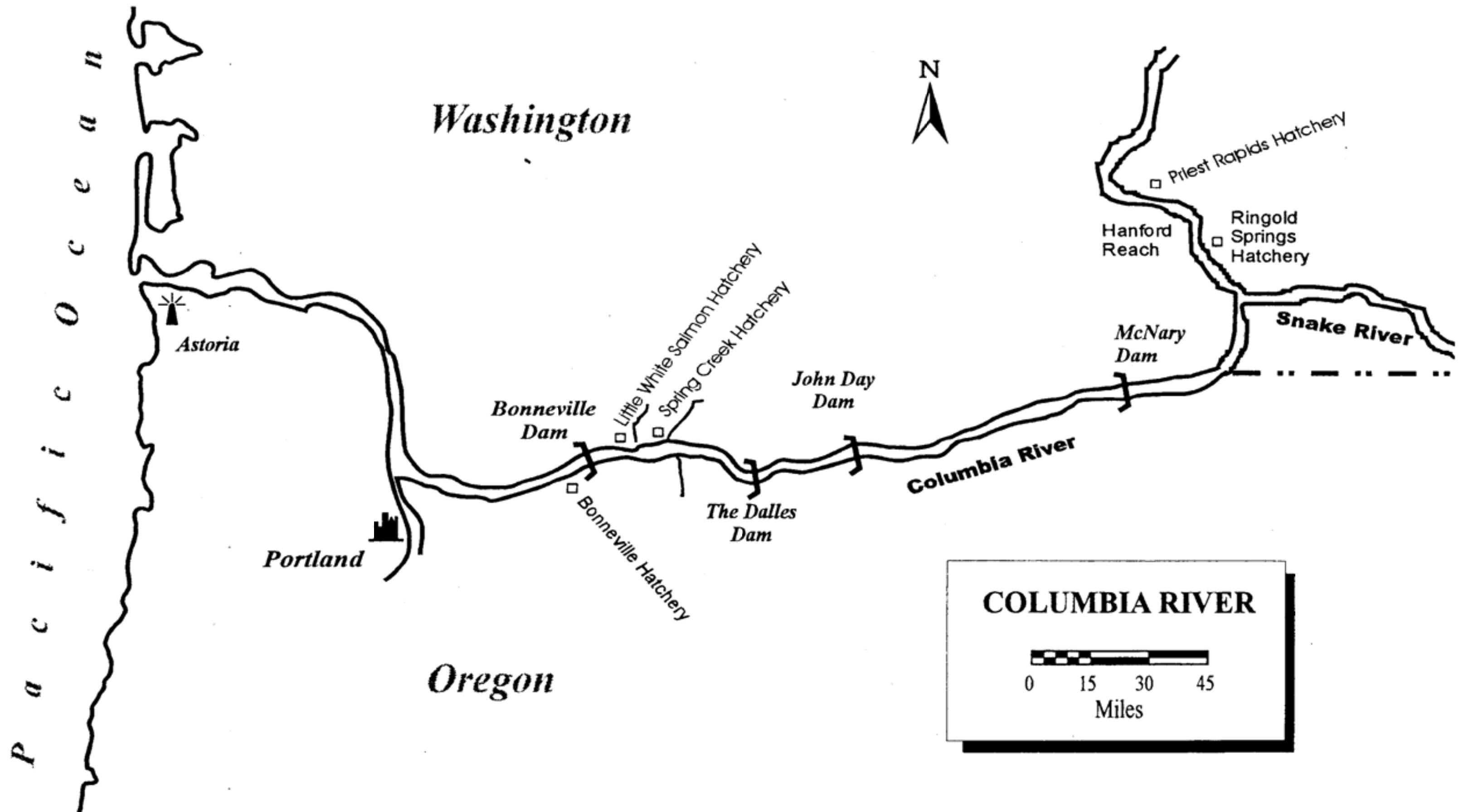

Figure 1. Location of dams, hatcheries, and production areas pertinent to the evaluation.

8) Investigation of feasibility of determining stock composition of juvenile fall chinook and chum rearing in the area described in Task 6.

9) Coded-wire tagging juvenile fall chinook captured in the area described in Task 6 to determine juvenile to adult survival rate.

METHODS AND MATERIALS

Adult Study

Spawning ground surveys of fall chinook and chum salmon below Bonneville Dam occurred from 07 October 2003 through 16 December 2003. The below Bonneville Dam study area is approximately two miles downstream from the dam, between river miles 141.0-143.5. The area includes Pierce and Ives Islands as well as the main channel of the Columbia River. Primary spawning areas are within the island complex and along the shorelines of the islands adjacent to the main channel of the Columbia River. Counts of spawning redds and numbers of live and dead fish were made from the bow of a jet boat and by wading in shallow water. In addition, locations of newly formed spawning redds were recorded using global positioning system (GPS) receivers.

Fish carcasses were examined and biological data was collected to profile stock for age composition, average size at return, and sex ratios. Scales from sampled fish were removed and analyzed to determine total age. To assist in determining stock origin of salmon found in the study areas, carcasses were inspected for fin clips. The snouts of fish with adipose fin clips were removed and kept for future coded-wire tag recovery and analysis. To assist in determining whether fish had successfully spawned, female carcasses were examined for the presence of eggs.

A capture-recapture carcass tagging study known as the Worlund technique was used to assist in providing spawner population estimates for fall chinook. The mathematical model used to analyze the data was developed by G. Paulik (prepared by D. Worlund) of the University of Washington and is a use of the multiple release and recapture methods of G. Seber and G. Jolly (Biometrika Vol. 49, 1962). The theory is described in Schwarz and Arnason, A. N. “A general methodology for the analysis of capture-recapture experiments in open populations” (Biometrics, 52, 860-873).

Each week newly discovered fall chinook carcasses were marked with a different colored plastic tag and returned to their original location. The number of new tags issued and the number of tags recovered from previous week’s tagging were recorded.

carcasses found with a tag were mutilated to identify them as recoveries. A population estimate was generated after tag data was analyzed by the above method.

Juvenile Study

The juvenile portion of the study concentrated on areas where spawning occurred below Bonneville Dam in 2003. In order to determine emergence timing of juvenile fall chinook and chum, estimated hatching and emergence dates were calculated in temperature units (TU) which are measured in Celsius degree-days. The dates were calculated in TU from the initiation of spawning to hatching of eggs (500 ^{o} C. TU for chinook and 600 ^{o} C. TU for chum) and beginning and ending of emergence (1,000 ^{o} C. TU for chinook and 825 ^{o} C. TU for chum (Keller, 2003)). Water temperatures used in TU calculations were taken from Bonneville Dam readings and from temperature gauges maintained by Battelle Pacific Northwest National Laboratories and located in the Ives Island area.

Sampling to determine the time and size juveniles that migrated from the areas used for rearing began 20 January 2004. Surveys were conducted twice weekly through 28 June 2004. Sampling was conducted in thirteen designated locations below Bonneville Dam (Figure 2). The locations were selected based on their proximity to redds identified during spawning ground surveys in 2003, representative habitat and seining accessibility. Specific sampling areas within the thirteen locations changed with variations in river flows.

Two types of gear were used to capture juvenile fish in the study area. Shorelines were fished with four-foot deep stick seines with one-eighth inch mesh in lengths of 18 and 28 feet. The sampling crew also employed a 100-foot long, beach seine with one-sixteenth inch mesh. After the seines were set, they were immediately retrieved. In-water fishing time was approximately five minutes. Seines worked best in sections of the river that were free of snags and large obstructions and with moderate flow velocities.

Captured fish were dip-netted into a five-gallon bucket containing the anesthetic MS-222. Once anesthetized, fish were identified by species, measured for fork length and examined for fin clips. Developmental stage of fry was also noted (e.g., yolk sac or button-up fry). Processing time was five to ten minutes per set. After data was collected, fish were returned to the site of capture. The number of sets fished, water temperatures and beginning and ending times for each sampling period were recorded. In addition, Bonneville Dam flows were noted and recorded for those periods when sampling occurred.

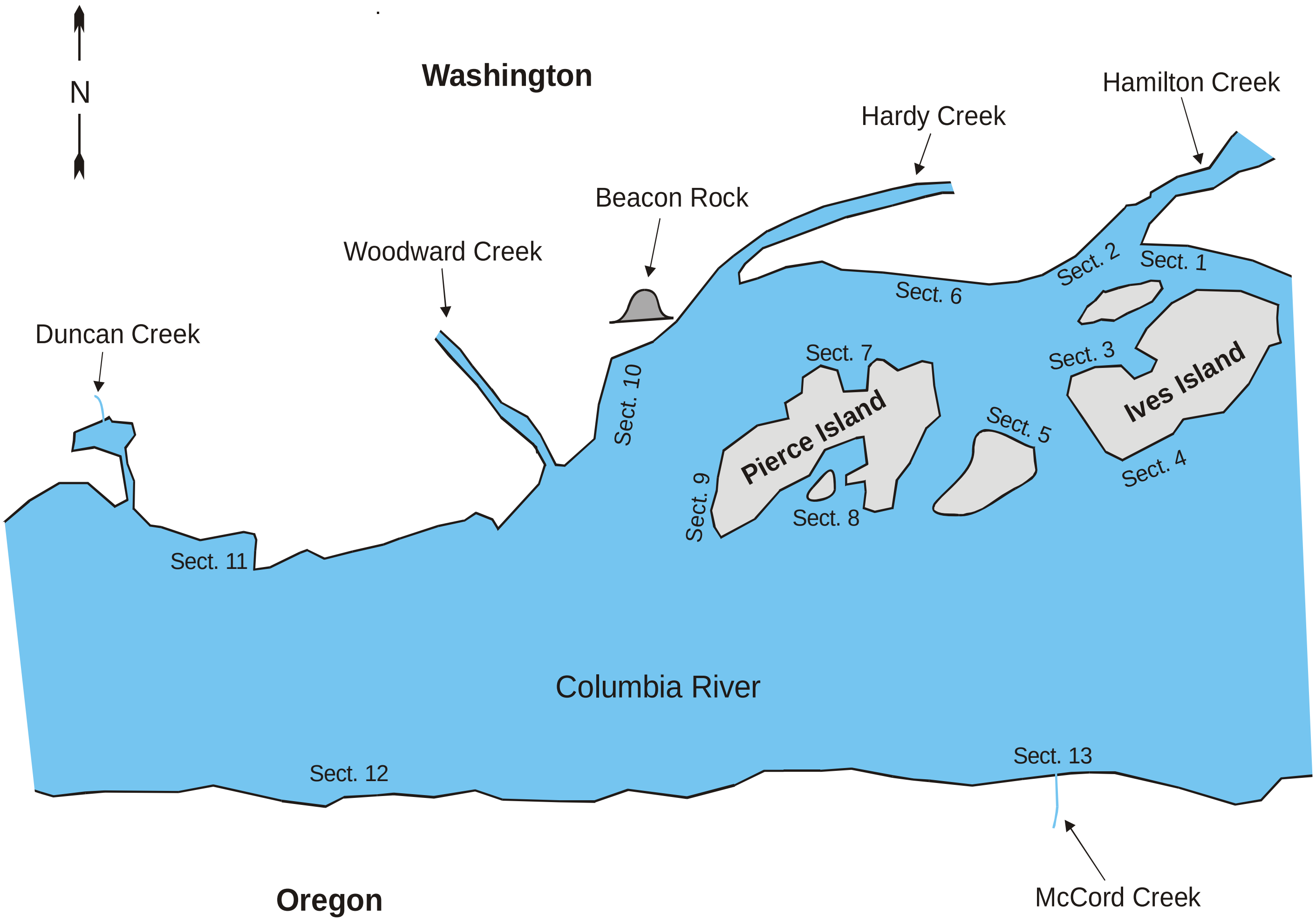

Figure 2. Locations of juvenile sampling sections below Bonneville Dam, 2004.

When unmarked juvenile chinook were caught in the study area, the criterion used for differentiating chinook juveniles that were products of the study area from upriver natural production and hatchery releases was based on the fork length of the sampled fish and presence of coded-wire tags. Chinook less than 65 mm fork length were assumed to be products of the study area. This assumption is based on the fact that chinook fry emerge at a size range of 35-40 mm fork length. In addition, hatcheries above Bonneville Dam release chinook at sizes greater than 65 mm fork length and wild upriver chinook juveniles do not begin migrating until they are larger than 65 mm fork length.

During the month of June, as the earliest hatching, juvenile chinook grew in size, the length criterion used to differentiate them from untagged hatchery fish was increased. At that time, juvenile chinook over 75 mm fork length were considered fish that were not products of the study area. The project was unable to determine whether chum captured in the study area, were products of main stem spawning or of nearby Hamilton and Hardy creeks, since all chum were unmarked and there are no size differences between the populations.

In order to determine a juvenile to adult survival rate for wild fall chinook found below Bonneville Dam, a part of the juvenile population was adipose fin clipped and coded-wire tagged. The tagging was conducted in the months of May and June 2004 when native fish began attaining a size of 47 mm fork length or greater. To avoid tagging fish from outside the area, tagging was terminated once fish of comparable size to the native population began migrating into the area from points above the dam. Evidence of juvenile chinook from outside the area was established when adipose fin clipped chinook in the 75-100 mm fork length range were caught in the study area.

Fish to be tagged were caught in the study area and held in a net pen for approximately 24 hours prior to tagging. They were then transported to the tagging site, anesthetized, measured, sorted, and a standard length coded-wire tag was inserted into the fish’s snout. After each fish was tagged, it was passed along a tag detector unit to ensure that a tag was present in the fish. The tagged fish was then placed into a recovery tank before being placed into a recovery net pen in the river. Several times a day fish were sacrificed to verify proper tag placement. At the end of each day, tagged fish were released downstream of the study area into the main channel of the Columbia River. In addition, each day approximately one percent of all tagged fish were held for 48 hours and checked for tag retention before being released.

RESULTS AND DISCUSSION

Adult Study

Spawning of fall chinook, chum and coho salmon below Bonneville Dam was documented by counts of live fish, redds and post-spawning mortality (Table 1). Based on spawning ground surveys, initiation of spawning below Bonneville Dam for bright stock fall chinook salmon was set at 7 October 2003 fall chinook. Initiation of spawning below Bonneville Dam for chum salmon was set at 4 November 2003.

Peak spawning for both fall chinook and chum salmon was determined to be approximately 24 November 2003. One hundred ninety redds, 318 live and 188 dead adults were observed at peak spawning for fall chinook. One hundred sixty-four redds, 281 live and 63 dead adults were observed at the time set for peak spawning for chum. The date determined to be the end of spawning for fall chinook was 16 December 2003. The time set as the end of spawning for chum is unknown since on 16 December 2003, our last survey date, we observed 15 live chum.

Table 2 contains the first, peak and last counts of spawning ground information from 1998 through 2003. For the six years the project has conducted spawning ground surveys below Bonneville Dam, estimated peak spawning time for bright chinook has been as early as 9 November (1999 and 2000) and as late as 24 November (2004). During the six years of the study, chum observed below Bonneville Dam have begun spawning the first week of November. The earliest peak spawning date for chum was 16 November in 1998 and the latest peak spawning date was 6 December 2002.

In 2003, coho salmon were also observed spawning in areas used by chinook and chum. Seven coded-wire tags were recovered from sampled carcasses. As in the previous six years of surveys, peak spawning appears to have occurred during the first two weeks of November. The coho observed in the area are of the early-spawning stock. This stock is produced at Bonneville Hatchery and is found spawning in Hardy and Hamilton creeks.

Ives Island fall chinook spawning times correspond to other late-spawning stocks of fall chinook found in the Columbia River. Timing of chum spawning below Bonneville Dam was similar to that of chum spawning in nearby Hardy and Hamilton creeks.

A bright, fall chinook population estimate was made based on results of carcass tagging. In 2003, it was estimated that 1,533 fall chinook returned to spawn in the areas around Ives and Pierce islands (Table 3). The population estimate of chinook should be considered a minimum estimate since fish were

Table 1. Columbia River mainstem spawning ground surveys, 2003.

Fall Chinook

Date	Redds	Live	Dead	Sampled	CWT Recoveries	Bonneville Dam tailwater (ft.)*	Bonneville Dam discharge (kcfs)*
10/07/2003	0	3	0	0	0	10.2	122.8
10/14/2003	0	0	2	2	0	8.9	104.4
10/21/2003	2	8	1	0	0	9.0	108.1
10/24/2003	0	1	0	0	0	11.6	133.8
10/28/2003	2	8	2	1	0	10.6	108.3
10/31/2003	10	52	2	0	0	10.4	124.3
11/04/2003	39	108	18	9	1	10.9	129.0
11/06/2003	59	157	6	0	0	11.4	132.5
11/10/2003	83	204	60	30	2	11.2	124.7
11/14/2003	134	266	59	0	0	11.1	130.2
11/18/2003	133	196	269	69	1	11.0	126.0
11/21/2003	175	189	50	0	0	11.4	125.8
11/24/2003	190	318	188	59	2	11.0	114.1
12/01/2003	0	0	215	42	1	11.2	129.4
12/02/2003	130	97	0	0	0	11.0	127.7
12/05/2003	93	58	0	0	0	11.6	118.8
12/09/2003	0	0	67	31	1	11.3	106.7
12/12/2003	30	20	8	0	0	11.5	97.4
12/16/2003	0	0	21	10	0	12.0	88.5
Total	1,080	1,633	968	253	8		

Chum

Date	Redds	Live	Dead	Sampled	Bonneville Dam tailwater (ft.)*	Bonneville Dam discharge (kcfs)*
10/07/2003	0	0	0	0	10.2	122.8
10/14/2003	0	0	0	0	8.9	104.4
10/21/2003	0	0	0	0	9.0	108.1
10/24/2003	0	0	0	0	11.6	133.8
10/28/2003	0	0	0	0	10.6	108.3
10/31/2003	0	0	0	0	10.4	124.3
11/04/2003	1	6	0	0	10.9	129.0
11/06/2003	4	33	0	0	11.4	132.5
11/10/2003	41	166	2	0	11.2	124.7
11/14/2003	114	296	2	0	11.1	130.2
11/18/2003	46	104	38	14	11.0	126.0
11/21/2003	193	149	37	0	11.4	125.8
11/24/2003	164	281	63	16	11.0	114.1
12/01/2003	0	0	111	37	11.2	129.4
12/02/2003	216	127	0	0	11.0	127.7
12/05/2003	262	171	0	0	11.6	118.8
12/09/2003	116	42	117	38	11.3	106.7
12/12/2003	187	46	36	0	11.5	97.4
12/16/2003	24	15	35	8	12.0	88.5
Total	1,368	1,436	441	113		

Coho

Date	Redds	Live	Dead	CWT Recoveries
10/07/2003	0	0	1	0
10/14/2003	0	9	3	1
10/21/2003	0	8	7	1
10/24/2003	0	5	5	0
10/28/2003	0	2	9	0
10/31/2003	0	9	1	0
11/04/2003	3	8	8	0
11/06/2003	10	28	7	0
11/10/2003	6	17	5	3
11/14/2003	0	12	0	0
11/18/2003	12	2	47	1
11/21/2003	0	0	7	0
11/24/2003	0	0	0	0
12/01/2003	0	0	13	1
12/05/2003	0	0	0	0
Total	31	100	113	7

* Daily readings taken at 12:00 pm (www.nwd-wc.army.mil/cgi-bin/DataQuery).

Table 2. Comparison of results from below Bonneville Dam spawning ground surveys, 1998-2003.

Fall Chinook

	Date	Redds	Live	Dead	Bonneville Dam tailwater (ft.)*	Bonneville Dam discharge (kcfs)*
First day of surveys:	10/26/1998**	16	9	3	8.8	100.4
	10/05/1999**	9	18	6	11.8	128.0
	09/19/2000	0	0	0	9.8	103.3
	10/03/2001	0	1	0	9.0	95.4
	10/08/2002**	7	10	11	9.0	80.3
	10/07/2003	0	3	0	10.2	122.8
Peak spawning day:	11/16/1998	198	242	82	11.5	125.3
	11/09/1999	152	268	71	13.2	143.8
	11/09/2000	225	225	23	11.7	123.1
	11/16/2001	31	107	21	9.2	106.5
	11/15/2002	214	515	125	11.4	131.6
	11/24/2003	190	318	188	11.0	114.1
Last day of surveys:	12/14/1998	0	0	8	14.9	158.2
	12/21/1999	0	0	0	19.1	218.7
	12/27/2000	no count	no count	1	12.9	135.7
	12/28/2001	0	2	1	12.4	124.2
	01/13/2003	0	0	0	11.5	121.2
	12/16/2003	no count	no count	21	12.0	88.5

Chum

	Date	Redds	Live	Dead	Bonneville Dam tailwater (ft.)*	Bonneville Dam discharge (kcfs)*
First day of surveys:	11/06/1998	0	13	0	11.6	125.0
	11/02/1999	0	3	0	12.6	119.7
	11/06/2000	15	18	0	11.2	126.6
	11/05/2001	0	10	0	8.2	84.8
	11/05/2002	4	5	0	10.8	117.6
	11/04/2003	1	6	0	10.9	129.0
Peak spawning day:	11/16/1998	47	110	2	11.5	125.3
	11/23/1999	29	40	1	15.3	172.2
	12/01/2000	95	215	34	11.6	128.4
	11/26/2001	181	239	16	11.1	116.7
	12/06/2002	776	1015	144	11.6	125.4
	11/24/2003	164	281	63	11.0	114.1
Last day of surveys:	12/14/1998	0	8	23	14.9	158.2
	12/21/1999	0	0	2	19.1	218.7
	01/03/2001	no count	0	3	11.7	136.9
	12/28/2001	0	0	4	12.4	124.2
	01/13/2003	0	0	78	11.5	121.2
	12/16/2003	24	15	27	12.0	88.5

* Daily readings taken at 12:00 pm (www.nwd-wc.army.mil/cgi-bin/DataQuery).

** Tule fall chinook counts.

Table 3. Number of bio-samples and population estimates of returning bright fall chinook and chum below Bonneville Dam,1998-2003.

Year	# chinook sampled for biological data	# chum sampled for biological data	population of chinook	population of chum
1998	244	118	554	226
1999	533	12	897	40
2000	451	195	704	529
2001	309	264	721	532
2002	364	472	1,881	4,232
2003	253	113	1,533	688

observed spawning in the deeper main channel areas where carcasses could not be recovered. This compares to an estimated spawning population of 1,881 adults in 2002, 721 adults in 2001 and 704 adults in 2000.

A population of 688 chum adults was estimated to have returned to spawn in the study area in 2003. This compares to an estimated population of 4,232 adults in 2002, 532 adults in 2001 and 529 adults in 2000. Spawning populations of 40 and 226 adults were estimated in 1999 and 1998, respectively.

Locations of newly observed salmon redds below Bonneville Dam were recorded using GPS waypoints. Figure 3 shows approximate locations of redds that were observed for the first time. The majority of fall chinook redds in 2003 were found 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. The majority of chum redds were observed near Hamilton Creek. These areas have been frequently used by chinook in past years.

The majority of chum redds were observed below Hamilton Creek and in an area on the northwest corner of Ives Island. Spawning chum were also found 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.

Vital statistics were developed from 221 fall chinook and 109 chum biological samples to assist in determining stock origins of returning fish found spawning in the study area. Vital statistics of bright fall chinook found below Bonneville Dam in 2003 include age compositions, mean fork lengths, and sex ratios (Table 4). Fall chinook sampled in the study area showed similarities in male, female, age class representation and age related mean fork lengths with other late-spawning fish found in the Columbia River such as Priest Rapids and Bonneville hatcheries stocks. Table 5 contains vital statistics of chum sampled below Bonneville Dam. Four-year-old fish were the predominant age classes in 2003 with females being the dominant sex (61.5%).

To further assist in determining the stock origin of salmon found below Bonneville Dam, all carcasses were sampled for fin clips and other external marks. Eight fall chinook carcasses were found to have adipose fin clips. Three of the carcasses contained coded-wire tags. All of the tagged fish were released as subyearlings from upriver bright fall chinook facilities above the study area. One fish was released from Bonneville Hatchery and two from Klickitat hatchery. There were no marked chum found.

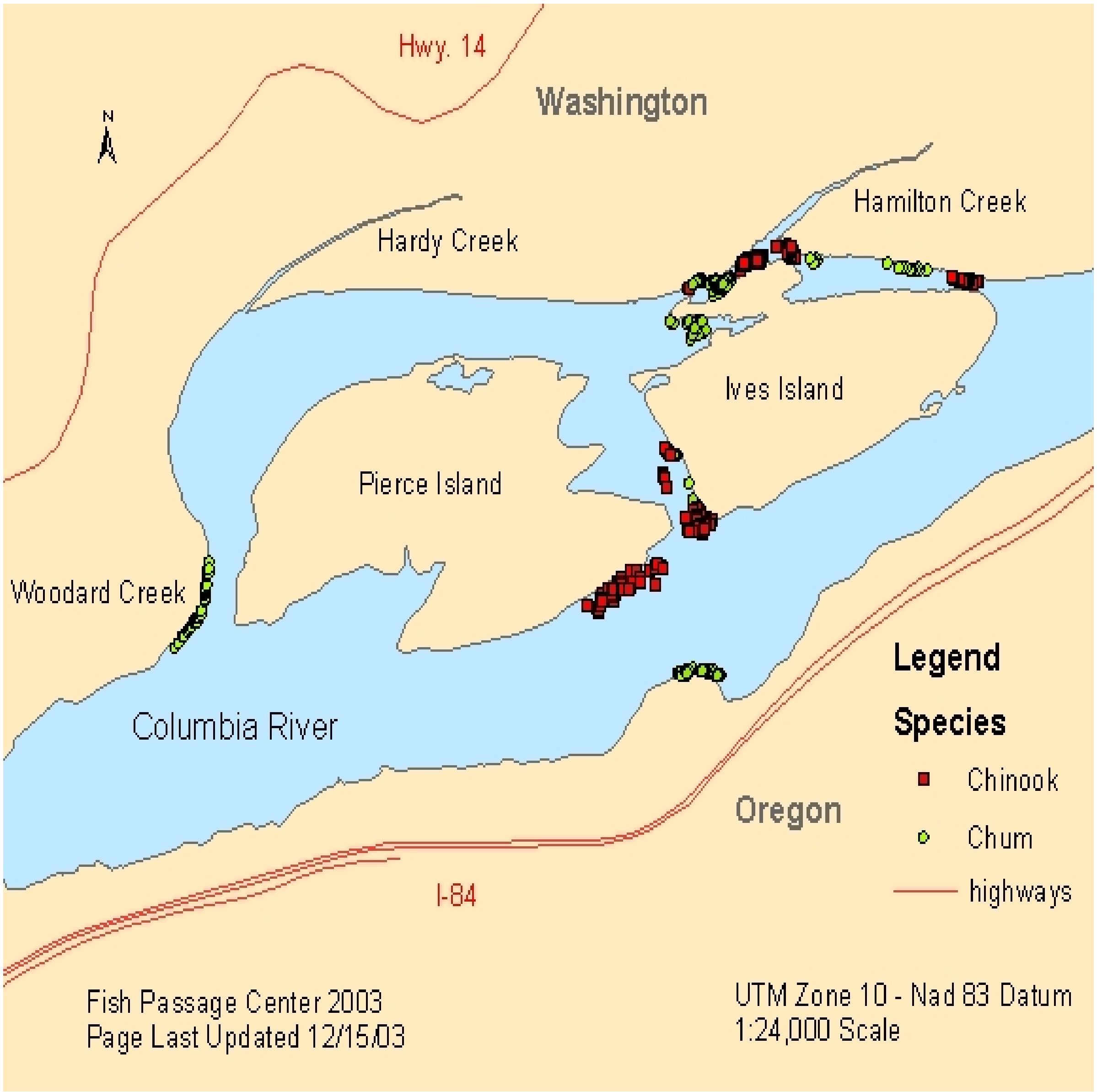

Figure 3. Location of fall chinook and chum redds below Bonneville Dam, 2003.

Table 4. Estimated age composition, sex composition, and fork length of tule fall chinok salmon that spawned below Bonneville Dam, 2003.

Age	Number in Sample		% in Sample		Mean Length (cm)		Length Range (cm)	
group	Males	Females	Males	Females	Males	Females	Males	Females
2	0	0	-	-	-	-	-	-
3	10	5	4.5	2.2	68	72	48-80	65-83
4	67	109	30.3	49.4	87	85	67-109	68-101
5	19	11	8.6	5.0	103	94	82-144	86-102
6	0	0	-	-	-	-	-	-
Total	96	125	43.4	56.6				

Table 5. Estimated age composition, sex composition, and fork length of chum salmon that spawned below Bonneville Dam, 2003.

Age	Number in Sample		% in Sample		Mean Length (cm)		Length Range (cm)	
group	Males	Females	Males	Females	Males	Females	Males	Females
2	0	0	-	-	-	-	-	-
3	0	4	-	3.7	-	67	-	63-71
4	37	56	34.0	51.3	81	71	88-73	88-61
5	5	7	4.5	6.5	81	75	87-76	80-72
Total	42	67	38.5	61.5				

WDFW geneticists analyzed GSI samples collected in 1998, 1999, 2000 and 2001. Their findings suggest that chum found spawning in the Columbia River around Ives Island show close genetic relationships with chum from nearby Hardy and Hamilton creeks. In addition, the report suggests it is reasonable to assume that the Ives Island chum population is included in the Lower Columbia River Chum Evolutionary Significant Unit (ESU) (Marshall, 1998).

Below Bonneville Dam, bright, fall chinook were sampled for GSI data by WDFW in 1996 and 1997. Analysis of 142 samples showed relatively small genetic differences between the below Bonneville Dam samples and samples taken from other Columbia River late-spawning stock, fall chinook. The analysis suggests, bright chinook spawning below Bonneville Dam are genetically similar to other bright fall chinook populations found in the Columbia River such as those found at the Hanford Reach and Bonneville Hatchery (Marshall, 1998).

Juvenile Study

Hatching and emergence times for 2003 brood salmon below Bonneville Dam are contained in Table 6. Hatching and emergence times of fall chinook and chum were estimated based on required temperature units that predict chinook and chum early life history and 2003-2004 Columbia River water temperatures taken in the study area.

Peizometers placed in the spawning area below the mouth of Hamilton Creek showed upwelling water to be warmer than the surrounding river water (Arntzen, 2002). The warmer water increases the water temperature in chum redds on average by several degrees Celsius. Using the temperature readings of gauges that recorded river temperatures below Hamilton Creek, emergence of chum was estimated to have occurred from 22 February to 15 April 2004. Estimated peak emergence of chum took place 25 March 2004.

Although some fall chinook spawned in the Hamilton Creek area, the majority of areas where fall chinook spawned were not subject to the above warmer upwelling phenomenon. Except in those areas shared by chum, emergence of bright fall chinook began approximately 6 January and continued through 28 April 2004. Peak emergence of fall chinook occurred 13 April 2004.

Table 6. Columbia River water temperature (^{o} F) and temperature units (^{o} C) below Bonneville Dam, 2003-2004.

(Data source: Battelle T1LB and T2LB piezometers thru June 18, 2004.)

	OCTOBER		NOVEMBER		DECEMBER		JANUARY		FEBURARY		MARCH		APRIL		MAY		JUNE	
	TEMP	TU's	TEMP	TU's	TEMP	TU's	TEMP	TU's	TEMP	TU's	TEMP	TU's	TEMP	TU's	TEMP	TU's	TEMP	TU's
DAY	(°F)	(°C)	(°F)	(°C)	(°F)	(°C)	(°F)	(°C)	(°F)	(°C)	(°F)	(°C)	(°F)	(°C)	(°F)	(°C)	(°F)	(°C)
1	65	18	56	13	49	10	43	6	42	6	44	7	48	9	54	12	58	15
2	66	19	51	10	49	9	45	7	41	5	44	7	48	9	54	12	59	15
3	68	20	55	13	49	10	45	7	41	5	43	6	49	9	55	13	58	15
4	65	18	54	12	47	8	41	5	42	5	44	6	49	9	55	13	60	15
5	65	19	54	12	47	8	40	5	42	5	43	6	49	10	55	13	60	15
6	66	19	53	11	46	8	39	4	42	6	43	6	49	10	55	13	60	15
7	66	19	53	12	47	8	37	3	42	6	45	7	50	10	55	13	59	15
8	66	17	53	12	47	9	39	4	43	6	46	8	50	10	56	13	59	15
9	62	17	54	12	47	8	39	4	45	7	46	8	50	10	57	14	60	15
10	62	17	55	13	46	8	43	6	44	7	46	8	51	10	57	14	60	15
11	59	15	55	13	47	8	43	6	43	6	45	7	51	10	56	14	59	15
12	59	15	54	12	46	8	42	6	44	7	45	7	51	11	57	14	59	15
13	60	16	52	11	45	7	40	4	44	7	46	8	51	11	57	14	59	15
14	59	15	53	12	45	7	43	6	44	6	46	8	52	11	57	14	59	15
15	56	14	53	12	45	7	42	5	45	7	47	8	51	11	57	14	59	15
16	62	16	53	12	46	8	39	4	44	7	45	7	51	11	57	14	60	15
17	62	17	50	10	45	7	42	6	44	7	47	8	51	11	57	14	60	16
18	62	17	50	10	45	7	41	5	42	6	46	8	51	11	57	14	61	16
19	62	17	50	10	45	7	41	5	41	5	45	7	52	11	57	14		
20	63	17	50	10	46	8	41	5	41	5	46	8	52	11	58	14		
21	63	17	51	10	46	8	40	4	45	7	47	8	52	11	57	14		
22	63	17	50	10	46	8	42	6	44	7	46	8	53	11	57	14		
23	63	17	50	10	45	7	41	5	43	6	47	8	53	11	57	14		
24	63	17	51	11	45	7	38	4	42	5	47	8	53	11	58	14		
25	62	17	52	11	46	8	42	5	41	5	47	8	53	12	58	15		
26	62	17	50	10	46	8	41	5	43	6	47	8	53	12	58	15		
27	62	17	50	10	47	8	39	4	43	6	47	8	54	12	59	15		
28	62	17	50	10	45	7	40	5	42	6	48	9	54	12	58	14		
29	62	16	51	10	45	7	39	4	45	7	48	9	54	12	58	14		
30	62	17	50	10	44	7	40	5			48	9	54	12	58	14		
31	62	17			43	6	40	5			48	9			58	14		
TOTAL	--	526	--	334	--	242	--	152	--	175	--	237	--	321	--	427	--	275
AVE.	63	17	52	11	46	8	41	5	43	6	46	8	51	11	57	14	36	9

REQUIRED TEMPERATURE UNITS (TU'S)

FALL CHINOOK	(°C)
EYE OUT	250
HATCHING	500
EMERGENCE	1000

CHUM	(°C)
EYE OUT	400
HATCHING	600
EMERGENCE	825

CUMULATIVE TU'S (°C) SINCE INITIATION AND END OF SPAWNING

FALL CHINOOK

				EMERGENCE		
EVENT	DATE	EYED OUT	HATCHING	G1[1]	River[2]	Bed[3]
BEGIN SPAWNING	10/7	10/24	11/16	3/7	1/6	12/7
PEAK SPAWNING	11/24	1/1	3/18	5/10	4/13	2/8
END SPAWNING	12/16	2/20	4/5	5/20	4/28	3/4

CHUM

				EMERGENCE		
EVENT	DATE	EYED OUT	HATCHING	G1[1]	River[2]	Bed[3]
BEGIN SPAWNING	11/4	12/26	3/2	4/6	2/22	12/29
PEAK SPAWNING	11/24	2/26	4/1	4/25	3/25	1/24
END SPAWNING	12/16	3/27	4/18	5/9	4/15	2/21

[1] **G1** guage is located at the head of Ives Island spawning area.

[2] **River** represents the emergence estimate based on average daily river temperatures taken from 2 guages within the Hamlilton Channel, above the substrate.

[3] **Bed** represents the emergence estimate based on average daily bed temperatures taken from 2 guages within the Hamlilton Channel, 56cm below the substrate.

Sampling for post-emergent fry took place in locations identified in Figure 2. Based on emergence estimates juvenile sampling began 20 January 2004. Sampling was terminated 28 June 2004 after it appeared the majority of juvenile fish had migrated from the study area. Catch rates of gear used to capture juvenile chum and fall chinook salmon are found in Table 7 and 8.

For juvenile chinook sampling, it appears the rate of success for both stick and beach seining methods was in some degree determined by flows in and around the study area. In the majority of sampling days where an increase in flow occurred, relative to the previous sampling day, there was a corresponding decrease in catch per unit effort. Also, where a decrease in flow occurred, relative to the previous sampling day, there was a corresponding increase in catch per unit effort. The inverse relationship between catch per unit of effort and flows was observed in sixty-four percent of the sampling days.

Deploying nets became difficult during high water events. Snags, fast water, limited riverbank access, and increased water depth prohibited successful net sets. In addition, due to faster flows during high water, juvenile fish were unable to hold in the sampling areas. Certain sampling areas were less affected by high water events because of their location in large back eddies and quiet pools. Although high water negatively affected catch throughout the juvenile sampling period, the total catch of juvenile chinook was significantly higher than past years, (total catch in 2001, 2002 and 2003 was 8,210, 5,487 and 6,877 respectively). Overall, favorable flow levels, improved gear, and earlier start times appear to be the primary reasons for the increase in catch.

A total of 25,433 juvenile chinook and 4,864 juvenile chum were sampled in areas below Bonneville Dam in 2004. Although juvenile fish were caught in all of the sampling sections around Ives and Pierce islands, some areas were more productive than other areas. Those areas that were closest to redds and or good rearing habitat seemed to yield the most catch. For chinook, these areas included sections five, eight and nine (Figure 4). Section five produced 26% of the total juvenile fall chinook catch in the area around the islands. Sections eight and nine yielded 25% and 12% of the total fish caught around the islands, respectively. Although sections three, six, seven and ten appeared to be used less frequently for rearing, those sections accounted for 25% of the total sampled fall chinook fry.

Figure five shows areas that produced catch of juvenile chum in 2004. Approximately 20% of the juvenile chum were caught in areas around Ives Island. Twenty-three percent of the total catch was in the section just below Hardy Creek. This area (section ten) likely contained large numbers of fish produced in Hardy Creek.

Table 7. Catch rates of juvenile chum caught with stick and beach seines below Bonneville Dam, 2004.

Week	Date	Total number caught	Number stick sets	Number caught in stick	Number beach sets	Number caught in beach	Total number sets	Fish caught per set	Bonneville Dam tailwater (ft.)*	Bonneville Dam discharge (kcfs)*
4	20-Jan	0	1	0	4	0	5	0.0	12.8	136.8
4	23-Jan	0	1	0	7	0	8	0.0	12.3	128.9
5	27-Jan	0	0	0	7	0	7	0.0	15.0	150.5
5	30-Jan	0	0	0	6	0	6	0.0	17.5	171.2
6	03-Feb	0	0	0	8	0	8	0.0	15.1	154.3
7	10-Feb	0	0	0	8	0	8	0.0	12.3	132.2
8	17-Feb	2	1	0	6	2	7	0.3	11.4	130.6
8	20-Feb	1	1	0	7	1	8	0.1	15.8	149.5
9	24-Feb	2	0	0	8	2	8	0.3	14.9	149.8
9	27-Feb	0	0	0	8	0	8	0.0	13.2	150.4
10	01-Mar	50	1	42	7	8	8	6.3	12.9	141.5
11	08-Mar	69	0	0	7	69	7	9.9	11.5	123.3
11	11-Mar	8	2	2	5	6	7	1.1	12.4	144.4
12	15-Mar	68	1	38	6	30	7	9.7	12.5	136.2
12	18-Mar	79	0	0	7	79	7	11.3	14.3	153.2
13	23-Mar	113	0	0	7	113	7	16.1	17.4	147.6
13	27-Mar	113	0	0	7	113	7	16.1	13.5	157.2
14	29-Mar	21	0	0	7	21	7	3.0	14.6	161.0
14	01-Apr	47	0	0	8	47	8	5.9	14.4	161.5
15	05-Apr	1,473	0	0	8	1473	8	184.1	12.4	137.7
15	08-Apr	2,205	0	0	8	2,205	8	275.6	14.6	158.5
16	12-Apr	339	1	37	6	302	7	48.4	13.9	154.9
16	15-Apr	103	2	14	6	89	8	12.9	16.4	201.3
17	19-Apr	133	2	19	6	114	8	16.6	15.7	198.1
17	22-Apr	17	1	1	7	16	8	2.1	18.5	210.8
18	27-Apr	12	1	0	7	12	8	1.5	14.5	189.3
18	30-Apr	0	5	0	0	0	5	0.0	15.7	199.1
19	03-May	5	1	2	5	3	6	0.8	14.7	191.3
19	06-May	1	1	0	6	1	7	0.1	19.2	245.7
20	10-May	1	0	0	7	1	7	0.1	16.6	228.8
20	13-May	2	0	0	6	2	6	0.3	20.4	246.3
	Totals	4,864	22	155	202	4,709	224	20.1		

* Daily readings taken at 12:00 pm.

Table 8. Catch rates of juvenile chinook caught with stick and beach seines below Bonneville Dam, 2004.

Week	Date	Total number caught	Number stick sets	Number caught in stick	Number beach sets	Number caught in beach	Total number sets	Fish caught per set	Bonneville Dam tailwater (ft.)*	Bonneville Dam discharge (kcfs)*
4	20-Jan	55	1	0	4	55	5	11.0	12.8	136.8
4	23-Jan	84	1	0	7	84	8	10.5	12.3	128.9
5	27-Jan	36	0	0	7	36	7	5.1	15.0	150.5
5	30-Jan	8	0	0	6	8	6	1.3	17.5	171.2
6	03-Feb	13	0	0	8	13	8	1.6	15.1	154.3
7	10-Feb	46	0	0	8	46	8	5.8	12.3	132.2
8	17-Feb	186	1	10	6	176	7	26.6	11.4	130.6
8	20-Feb	10	1	0	7	10	8	1.3	15.8	149.5
9	24-Feb	52	0	0	8	52	8	6.5	14.9	149.8
9	27-Feb	24	0	0	8	24	8	3.0	13.2	150.4
10	01-Mar	512	1	496	7	16	8	64.0	12.9	141.5
11	08-Mar	22	0	0	7	22	7	3.1	11.5	123.3
11	11-Mar	47	2	2	5	45	7	6.7	12.4	144.4
12	15-Mar	397	1	362	6	35	7	56.7	12.5	136.2
12	18-Mar	173	0	0	7	173	7	24.7	14.3	153.2
13	23-Mar	176	0	0	7	176	7	25.1	17.4	147.6
13	27-Mar	780	0	0	7	780	7	111.4	13.5	157.2
14	29-Mar	295	0	0	7	295	7	42.1	14.6	161.0
14	01-Apr	329	0	0	8	329	8	41.1	14.4	161.5
15	05-Apr	1,486	0	0	8	1,486	8	185.8	12.4	137.7
15	08-Apr	2,292	0	0	8	2,292	8	286.5	14.6	158.5
16	12-Apr	2,114	1	87	6	2,027	7	302.0	13.9	154.9
16	15-Apr	1,878	2	351	6	1,527	8	234.8	16.4	201.3
17	19-Apr	1,531	2	487	6	1,044	8	191.4	15.7	198.1
17	22-Apr	774	1	6	7	768	8	96.8	18.5	210.8
18	27-Apr	1,753	1	114	7	1,639	8	219.1	14.5	189.3
18	30-Apr	387	5	387	0	0	5	77.4	15.7	199.1
19	03-May	1,536	1	77	5	1,459	6	256.0	14.7	191.3
19	06-May	943	1	201	6	742	7	134.7	19.2	245.7
20	10-May	1,295	0	0	7	1,295	7	185.0	16.6	228.8
20	13-May	536	0	0	6	536	6	89.3	20.4	246.3
21	17-May	990	0	0	7	990	7	141.4	18.2	240.7
21	20-May	664	0	0	6	664	6	110.7	19.2	255.8
22	24-May	251	1	11	6	240	7	35.9	20.5	261.9
22	27-May	577	1	185	5	392	6	96.2	20.7	286.0
23	01-Jun	313	0	0	7	313	7	44.7	20.1	275.0
23	04-Jun	583	0	0	7	583	7	83.3	19.5	270.3
24	08-Jun	488	0	0	7	488	7	69.7	19.7	273.1
24	11-Jun	418	1	41	6	377	7	59.7	20.3	276.3
25	14-Jun	273	0	0	7	273	7	39.0	21	273.8
25	17-Jun	322	1	21	7	301	8	40.3	17.2	232.5
26	21-Jun	246	0	0	7	246	7	35.1	19.6	245.5
26	24-Jun	403	0	0	8	403	8	50.4	15.2	192.4
27	28-Jun	135	0	0	7	135	7	19.3	15.4	211.2
	Totals	25,433	26	2,838	289	22,595	315	80.7		

* Daily readings taken at 12:00 pm.

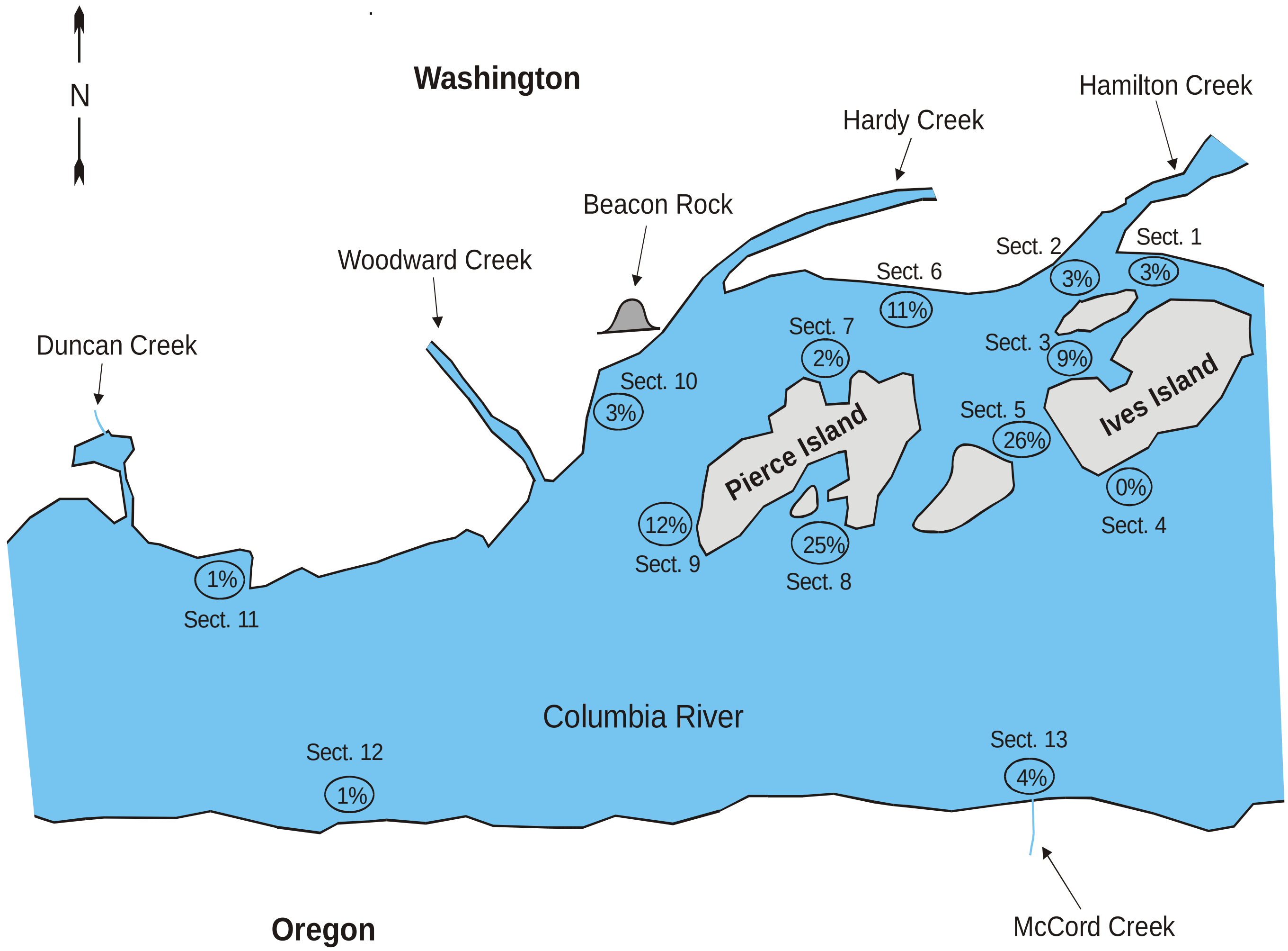

Figure 4. Percent of total juvenile chinook catch by section, below Bonneville Dam, 2004.

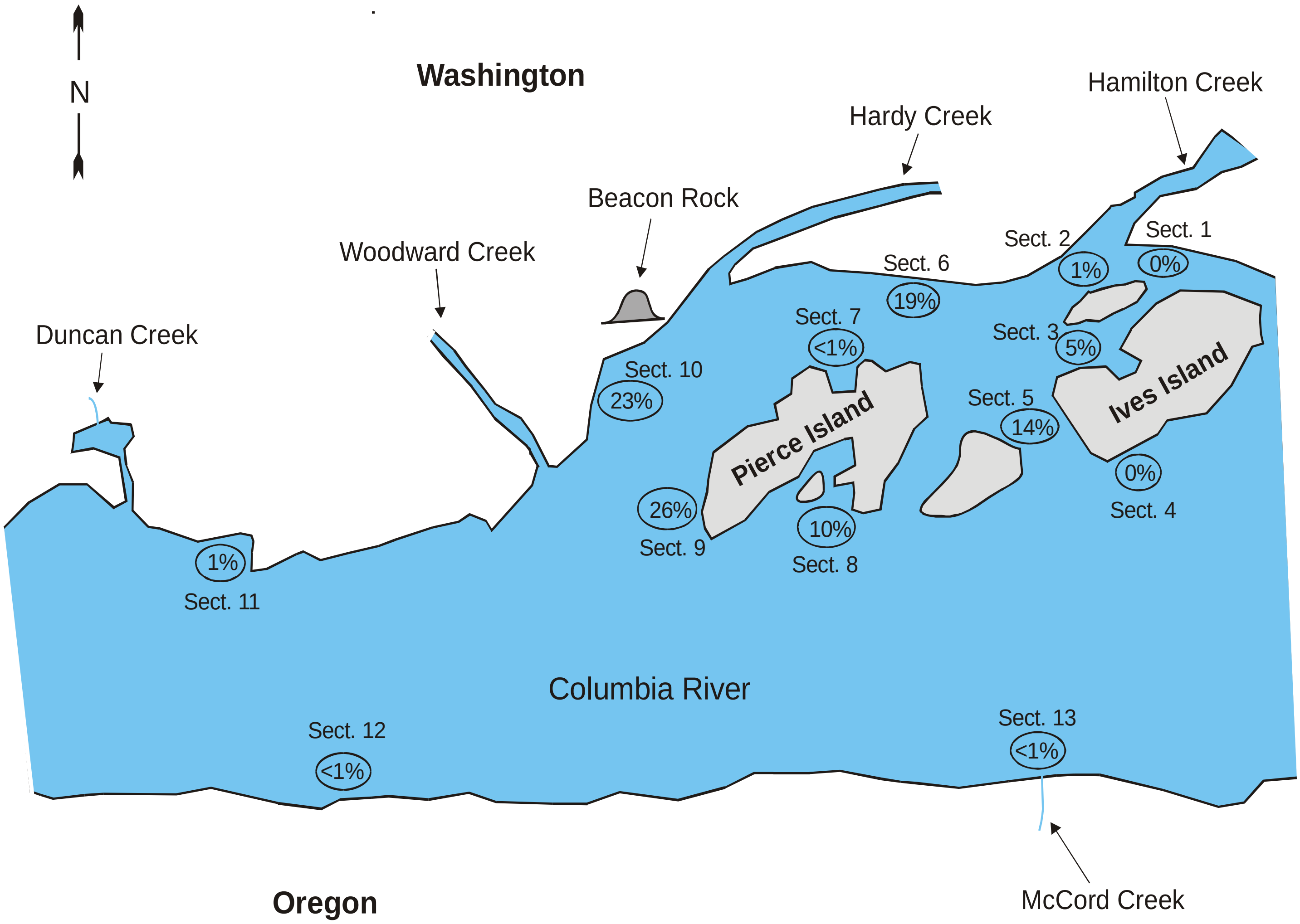

Figure 5. Percent of total juvenile chum catch by section, below Bonneville Dam, 2004.

Results of juvenile chum sampling are found in Table 9. Juvenile chum were caught and sampled from 17 February to 13 May 2004. Peak catch of juvenile chum occurred 8 April 2004. Mean length of sampled juvenile chum for the season was 42.2 mm fork length. Once chum attained a size of approximately 45 mm fork length, they began migrating from the area. It appears that by the end of April the majority of chum had migrated from below Bonneville Dam.

Fork length distribution of sampled juvenile fall chinook is found in Table 10. The table shows the length distribution of juveniles caught in the study area during the sampling season. Newly emerged fish (juveniles less than 40 mm in length) were present in the catch from 20 January to 24 June. Peak catch of recently emerged juvenile chinook (those fish less than 50 mm in fork length), was observed to be 19 April. Peak catch of chinook fry in all size categories less than 100 mm was 8 April.

Mean fork length of chinook rearing in the study area increased as water temperatures increased below Bonneville Dam. From 17 February to 3 May, mean fork length of sampled juvenile chinook increased from 40.9 mm to 44.7 mm, a growth rate of approximately 0.05 mm/day. During this time period daily water temperatures increased from 38 to 53 ^{o}F. From 3 May to 21 June, mean fork length increased from 44.7 mm to 64.7 mm, a growth rate of approximately 0.41 mm/day. During this time period, daily water temperatures increased from 53 to 63 ^{o}F. Wild juvenile chinook reared in areas below Bonneville Dam until they attained a size of approximately 65 to 80 mm in fork length. Once they attained this size, they began migrating from the area. Peak migration of study area chinook occurred during the month of June.

To assist in determining stock composition of fish using the rearing areas below Bonneville Dam, all captured juvenile chinook were examined for fin marks. Identifying hatchery released juveniles with adipose fin clips aided in determining stock composition of fish using the area below Bonneville Dam. When hatchery fish with fin clips appeared below the dam, they were typically of a larger size than the wild chinook rearing below Bonneville Dam. This was especially noticeable during the months of February through April when Spring Creek National Fish Hatchery made early-spawning stock, fall chinook releases above Bonneville Dam. Since the unmarked component of the hatchery releases were approximately the same size as the marked component, study area wild fish could be differentiated from hatchery-released chinook. This rule of thumb was useful until late June when migrating subyearling chinook of similar size than the native bright stock chinook began appearing in the study area. In 2004, less than 0.36% of juvenile fall chinook sampled were fin clipped. Numbers and mean length of fin-clipped juvenile chinook caught and sampled below Bonneville Dam are presented in Table 11.

Table 9. Fork length distribution of juvenile chum sampled below Bonneville Dam, 2004.

				Number of chum in millimeters									Bonneville Dam tailwater	discharge	water
Week	Date	Total	Range	30-39	40-49	50-59	60-69	70-79	80-89	90-100	> 100	Mean length	(ft.)*	(kcfs)*	temp. (°F)
4	20-Jan	0	-	-	-	-	-	-	-	-	-	-	12.8	136.8	35
4	23-Jan	0	-	-	-	-	-	-	-	-	-	-	12.3	128.9	35
5	27-Jan	0	-	-	-	-	-	-	-	-	-	-	15.0	150.5	35
5	30-Jan	0	-	-	-	-	-	-	-	-	-	-	17.5	171.2	38
6	03-Feb	0	-	-	-	-	-	-	-	-	-	-	15.1	154.3	38
7	10-Feb	0	-	-	-	-	-	-	-	-	-	-	12.3	132.2	38
8	17-Feb	2	38 - 39	2	-	-	-	-	-	-	-	38.5	11.4	130.6	38
8	20-Feb	1	39	1	-	-	-	-	-	-	-	39.0	15.8	149.5	38
9	24-Feb	2	40 - 42	-	2	-	-	-	-	-	-	41.0	14.9	149.8	38
9	27-Feb	0	-	-	-	-	-	-	-	-	-	-	13.2	150.4	38
10	01-Mar	50	38 - 49	7	43	-	-	-	-	-	-	41.7	12.9	141.5	39
11	08-Mar	69	35 - 44	32	37	-	-	-	-	-	-	39.4	11.5	123.3	40
11	11-Mar	8	39 - 49	1	7	-	-	-	-	-	-	45.0	12.4	144.4	40
12	15-Mar	68	35 - 47	13	55	-	-	-	-	-	-	41.8	12.5	136.2	42
12	18-Mar	79	38 - 54	10	68	1	-	-	-	-	-	41.8	14.3	153.2	43
13	23-Mar	113	35 - 47	35	78	-	-	-	-	-	-	40.7	17.4	147.6	44
13	27-Mar	113	35 - 52	27	84	2	-	-	-	-	-	40.9	13.5	157.2	45
14	29-Mar	21	35 - 42	7	14	-	-	-	-	-	-	39.9	14.6	161.0	46
14	01-Apr	47	35 - 46	13	34	-	-	-	-	-	-	40.8	14.4	161.5	46
15	05-Apr	1,473*	35 - 48	154	692	-	-	-	-	-	-	40.8	12.4	137.7	47
15	08-Apr	2,205*	34 - 58	234	523	9	-	-	-	-	-	40.8	14.6	158.5	48
16	12-Apr	339*	35 - 64	33	246	23	2	-	-	-	-	43.8	13.9	154.9	49
16	15-Apr	103	36 - 52	14	85	4	-	-	-	-	-	43.4	16.4	201.3	49
17	19-Apr	133	37 - 55	18	104	11	-	-	-	-	-	43.3	15.7	198.1	50
17	22-Apr	17	35 - 51	6	10	1	-	-	-	-	-	41.9	18.5	210.8	51
18	27-Apr	12	39 - 57	3	6	3	-	-	-	-	-	43.6	14.5	189.3	51
18	30-Apr	0	-	-	-	-	-	-	-	-	-	-	15.7	199.1	52
19	03-May	5	42 - 52	-	4	1	-	-	-	-	-	44.8	14.7	191.3	53
19	06-May	1	47	-	1	-	-	-	-	-	-	44.7	19.2	245.7	54
20	10-May	1	49	-	1	-	-	-	-	-	-	46.8	16.6	228.8	55
20	13-May	2	42 - 56	-	1	1	-	-	-	-	-	46.3	20.4	246.3	55
Totals*		4,864		610	2,095	56	2					42.2			

* Totals include additional fish that were not sampled for fork length.

Table 10. Fork length distribution of juvenile chinook sampled below Bonneville Dam, 2004.

															Bonneville Dam		
				Number of chinook in millimeters								Mean length	% chinook		tailwater	discharge	water
Week	Date	**Total**	Range	30-39	40-49	50-59	60-69	70-79	80-89	90-100	> 100	chf < 150mm	< 60mm	60-100mm	(ft.)*	(kcfs)*	temp. (^{o}F)
4	20-Jan	**55**	38 - 145	4	6	-	-	-	-	5	40	40.1	67	33	12.8	136.8	35
4	23-Jan	**84**	40 - 139	-	4	-	-	-	3	13	64	41.5	20	80	12.3	128.9	35
5	27-Jan	**36**	35 - 135	3	12	-	-	-	-	5	16	42.4	75	25	15.0	150.5	35
5	30-Jan	**8**	35 - 46	4	4	-	-	-	-	-	-	40.0	100	0	17.5	171.2	38
6	03-Feb	**13**	34 - 144	6	5	-	-	-	-	1	1	38.7	92	8	15.1	154.3	38
7	10-Feb	**46**	32 - 125	13	1	-	-	-	1	6	25	37.3	67	33	12.3	132.2	38
8	17-Feb	**186**	35 - 52	52	131	3	-	-	-	-	-	40.9	100	0	11.4	130.6	38
8	20-Feb	**10**	37 - 43	5	5	-	-	-	-	-	-	39.6	100	0	15.8	149.5	38
9	24-Feb	**52**	37 - 114	5	23	2	-	-	1	11	10	42.8	71	29	14.9	149.8	38
9	27-Feb	**24**	37 - 128	6	3	-	-	-	1	4	10	40.1	64	36	13.2	150.4	38
10	01-Mar	**512**	33 - 106	44	434	24	1	-	-	4	5	43.8	99	1	12.9	141.5	39
11	08-Mar	**22**	35 - 69	7	8	-	7	-	-	-	-	49.1	68	32	11.5	123.3	40
11	11-Mar	**47**	37 - 68	5	33	3	6	-	-	-	-	45.9	87	13	12.4	144.4	40
12	15-Mar	**397**	35 - 112	75	222	23	64	11	-	-	2	46.7	81	19	12.5	136.2	42
12	18-Mar	**173**	34 - 114	35	65	4	44	23	-	-	2	51.8	61	39	14.3	153.2	43
13	23-Mar	**176**	34 - 74	66	105	1	1	3	-	-	-	41.0	98	2	17.4	147.6	44
13	27-Mar	**780 ***	34 - 126	290	325	6	16	21	-	1	5	41.8	94	6	13.5	157.2	45
14	29-Mar	**295**	35 - 76	103	184	4	4	-	-	-	-	40.8	99	1	14.6	161.0	46
14	01-Apr	**329**	35 - 131	63	203	16	10	18	2	1	16	45.2	86	9	14.4	161.5	46
15	05-Apr	**1,486 ***	34 - 142	118	487	7	3	5	1	-	1	41.9	98	1	12.4	137.7	47
15	08-Apr	**2,292 ***	33 - 79	215	672	18	3	5	-	-	-	42.0	99	1	14.6	158.5	48
16	12-Apr	**2,114 ***	35 - 164	73	528	56	9	5	10	-	2	45.1	96	4	13.9	154.9	49
16	15-Apr	**1878 ***	34 - 156	183	708	59	12	15	8	-	6	43.9	96	4	16.4	201.3	49
17	19-Apr	**1531 ***	35 - 152	131	900	151	24	13	21	9	15	45.7	94	5	15.7	198.1	50
17	22-Apr	**774**	35 - 140	113	583	45	2	2	23	5	1	44.5	96	4	18.5	210.8	51
18	27-Apr	**1,753 ***	36 - 142	121	687	71	10	13	20	13	1	45.7	94	6	14.5	189.3	51
18	30-Apr	**387**	36 - 95	59	297	26	1	1	2	1	-	44.2	99	1	15.7	199.1	52
19	03-May	**1,536 ***	34 - 121	108	632	81	8	4	4	3	1	44.7	98	2	14.7	191.3	53
19	06-May	**943**	34 - 96	122	677	139	3	-	1	1	-	44.7	99	1	19.2	245.7	54
20	10-May	**1,295 ***	34 - 142	106	739	184	7	2	10	11	7	46.8	97	3	16.6	228.8	55
20	13-May	**536**	34 - 100	69	370	73	4	1	6	13	-	46.3	96	4	20.4	246.3	55
21	17-May	**990 ***	35 - 132	41	450	125	47	9	2	13	6	49.2	89	10	18.2	240.7	55
21	20-May	**664 ***	35 - 115	44	321	131	45	25	12	25	3	51.7	82	18	19.2	255.8	56
22	24-May	**251**	36 - 126	16	134	63	19	6	2	6	5	51.5	85	13	20.5	261.9	56
22	27-May	**577**	36 - 125	39	218	177	82	36	16	4	5	53.7	75	24	20.7	286.0	57
23	01-Jun	**313**	38 - 113	12	144	102	38	11	3	1	2	51.9	82	17	20.1	275.0	56
23	04-Jun	**583**	37 - 98	7	138	147	181	86	20	4	-	58.9	50	50	19.5	270.3	58
24	08-Jun	**488**	38 - 94	2	89	87	172	110	19	9	-	62.4	36	64	19.7	273.1	58
24	11-Jun	**418**	37 - 116	4	71	63	115	116	43	4	2	64.5	33	67	20.3	276.3	58
25	14-Jun	**273**	39 - 109	1	11	30	77	104	41	7	2	70.7	15	84	21.0	273.8	57
25	17-Jun	**322**	39 - 93	1	16	80	100	95	26	4	-	65.8	30	70	17.2	232.5	58
26	21-Jun	**246**	40 - 213	-	13	72	76	67	13	4	1	64.7	35	65	19.6	245.5	60
26	24-Jun	**403**	36 - 236	1	12	41	96	150	88	12	3	72.1	13	86	15.2	192.4	62
27	28-Jun	**135**	47 - 87	-	3	14	42	51	25	-	-	70.7	13	87	15.4	211.2	63
Totals*		25,433		2,372	10,673	2,128	1,329	1,008	424	200	259						

* Totals include additional fish that were not sampled for fork length.

Table 11. Adipose fin clipped fall chinook sampled below Bonneville Dam, 2004.

Week	Date	Number of marked fish sampled	Fork Length range (mm)	Mean length(mm)	Total chinook sampled for fin marks	% of sample marked
4	20-Jan	-	-	-	55	-
4	23-Jan	-	-	-	84	-
5	27-Jan	-	-	-	36	-
5	30-Jan	-	-	-	8	-
6	03-Feb	1	144	144.0	13	7.69
7	10-Feb	-	-	-	46	-
8	17-Feb	-	-	-	186	-
8	20-Feb	-	-	-	10	-
9	24-Feb	-	-	-	52	-
9	27-Feb	-	-	-	24	-
10	01-Mar	-	-	-	512	-
11	08-Mar	-	-	-	22	-
11	11-Mar	-	-	-	47	-
12	15-Mar	3	67 - 73	69.3	397	0.76
12	18-Mar	1	58	58.0	173	0.58
13	23-Mar	-	-	71.0	176	-
13	27-Mar	-	-	69.0	780	-
14	29-Mar	-	-	76.0	295	-
14	01-Apr	2	72 - 75	73.5	329	0.60
15	05-Apr	1	142	142.0	1,486	0.07
15	08-Apr	1	66	66.0	2,292	0.04
16	12-Apr	1	164	164.0	2,114	0.05
16	15-Apr	4	80 - 156	126.3	1,878	0.21
17	19-Apr	18	74 - 152	117.9	1,531	1.18
17	22-Apr	2	79 - 140	109.5	774	0.26
18	27-Apr	2	88 - 142	115.0	1,753	0.11
18	30-Apr	-	-	-	387	-
19	03-May	1	121	121.0	1,536	0.07
19	06-May	-	-	-	943	-
20	10-May	3	84 - 142	120.3	1,295	0.23
20	13-May	-	-	-	536	-
21	17-May	-	-	-	990	-
21	20-May	-	-	-	664	-
22	24-May	-	-	-	251	-
22	27-May	3	54 - 58	56.3	577	0.52
23	01-Jun	2	64	64.0	313	0.64
23	04-Jun	-	-	-	583	-
24	08-Jun	3	79 - 94	87.7	488	0.61
24	11-Jun	14	65 - 88	77.3	418	3.35
25	14-Jun	3	85 - 93	88.0	273	0.11
25	17-Jun	10	63 - 93	76.5	322	3.11
26	21-Jun	1	213	213.0	246	0.41
26	24-Jun	14	63 - 85	75.4	403	3.47
27	28-Jun	2	70 - 87	78.5	135	1.48
Totals		92		98.4	25,433	0.36

No marked chum were observed in the juvenile sampling, since no chum hatchery facilities exist above Bonneville Dam and nearby Hardy Creek and Hamilton Creek chum are not fin marked for assessment purposes. This being the case, chum produced from spawners in the mainstem Columbia River could not be differentiated from populations from nearby creeks.

To determine a juvenile to adult survival rate for wild bright stock fall chinook found below Bonneville Dam, a portion of the juvenile population was adipose fin clipped and coded-wire tagged. The tagging was conducted in the months of May and June 2004, when mean fork length of juvenile fish met the minimum size criterion of 47 mm fork length. Table 12 provides results of the tagging project including total number of chinook handled, number of tagged fish, number of fish released, mortality rate and mean length of tagged fish.

To avoid tagging fish from outside the area, chinook greater than 75 mm fork length were not tagged. Coded-wire tagging of wild juvenile fall chinook began 4 May when sampling data showed that approximately 23% of sampled fry were of minimum taggable size (47 mm fork length). The project was able to tag and release 24,657 chinook in 2004. Tagging was terminated 16 June when it became obvious that only small numbers of taggable fish remained around the Ives and Pierce islands. The mortality rate of tagged fish prior to release was 3.7%.

SUMMARY AND CONCLUSIONS

In 2003, a total of 253 adult fall chinook and 113 chum were sampled for biological data in the study area. Peak spawning time below Bonneville Dam for fall chinook was set at approximately 24 November. Peak spawning time for chum occurred approximately 24 November. There were estimated to be a total of 1,533 bright fall chinook spawning in the study area below Bonneville Dam in 2003. The 2003 study area chum population below Bonneville Dam was estimated to be 688 spawning fish.

Temperature unit data suggests that below Bonneville Dam 2003 brood chinook emergence began on 6 January and ended 28 April 2004, with peak emergence occurring 13 April. 2003 brood juvenile chum emergence below Bonneville Dam began 22 February and continued through 15 April 2004. Peak chum emergence below Bonneville Dam took place 25 March. A total of 25,433 juvenile chinook and 4,864 juvenile chum were sampled between the dates of 20 January and 28 June 2004 below Bonneville Dam. Juvenile chum migrated from the study area in the 40-55 mm fork length range. Migration of chum occurred during the months of March, April and May, with the majority of migration taking place in April. Sampling results suggest that the majority of bright stock, fall chinook migration from took place during the month of June 2004 when juvenile fall chinook were in the 65 to 80 mm fork length size range.

Table 12. Wild juvenile fall chinook tagged and released below Bonneville Dam, 2004.

Date	Tag code	Number sampled	Number tagged	Tagged mortallity	Tagged percent mortality	Number tagged released	Sampled mean fork length	Untaggable fish (<47 or >70mm.)	Percent taggable	Water temp. ^{o}F
05/04/04	09/35/22	2,303	529	0	0	529	42.0	1,774	23.0	56
05/05/04	"	5,055	614	33	5.4	581	43.5	4,441	12.1	52
05/06/04	"	6,140	616	0	0	616	40.2	5,524	10.0	55
05/11/04	"	1,659	723	4	0.6	719	43.5	936	43.6	52
05/12/04	"	2,669	1,325	25	1.9	1,300	46.4	1,344	49.6	58
05/13/04	"	3,545	1,065	23	2.2	1,042	45.9	2,480	30.0	48
05/18/04	"	2,557	1,820	64	3.5	1,756	48.9	737	71.2	-
05/19/04	"	2,198	1,482	28	1.9	1,454	52.1	716	67.4	54
05/20/04	09/35/22,21	1,396	870	61	7.0	809	51.3	526	62.3	57
05/25/04	09/35/21	2,176	1,808	36	2	1,772	56.2	368	83.1	60
05/26/04	"	2,535	1,731	37	2.1	1,694	54.5	804	68.3	58
05/27/04	"	2,670	2,073	26	1.3	2,047	54.7	597	77.6	57
06/02/04	"	1,754	1,275	16	1.3	1,259	58.4	479	72.7	58
06/03/04	09/35/21,40/25	1,197	883	4	0.5	879	61.4	314	73.8	58
06/04/04	09/35/21,40/25	1,349	1,013	72	7.1	941	59.0	336	75.1	58
06/08/04	09/35/21,40/25	2,493	1,997	92	4.6	1,905	62.1	496	80.1	57
06/09/04	09/35/21,40/25	1,555	960	104	10.8	856	58.0	595	61.7	59
06/10/04	09/40/25,40/26	1,647	1,212	141	11.6	1,071	64.2	435	73.6	59
06/11/04	09/40/26	1,351	1,135	66	5.8	1,069	64.4	216	84.0	54
06/15/04	09/40/26	1,728	1,277	41	3.2	1,236	64.0	451	73.9	57
06/16/04	09/40/26	1,696	1,167	45	3.9	1,122	67.0	529	68.8	60
Totals		49,673	25,575	918	3.7	24,657	54.2	24,098	51.5	

Adult and juvenile sampling below Bonneville Dam provided information to assist in determining the stock of fall chinook and chum spawning and rearing just below Bonneville Dam. Based on observed spawning times, adult age and sex composition, GSI analysis, juvenile emergence timing, juvenile migration timing and juvenile size at the time of migration, it appears that in 2003 and 2004 the majority of fall chinook using the study areas below Bonneville Dam were a late-spawning, bright stock of fall chinook. Observed spawning times, adult age and sex composition, GSI analysis, juvenile emergence timing, juvenile migration timing and juvenile size at the time of migration suggests chum spawning and rearing in the study area are similar to stocks of chum found in Hamilton and Hardy creek and part of the Lower Columbia River Chum ESU.

PLANS FOR FY 2005

We are planning to continue collecting data to determine the status of fall chinook and chum spawning below Bonneville Dam. We are planning to collect biological data from the fish spawning below Bonneville Dam and along both shorelines below Bonneville Dam. Biological data and coded-wire tag recoveries will be used to profile stocks and determine stock origins.

We will continue to estimate emergence timing of juvenile fall chinook and chum below Bonneville Dam. We are planning to sample juvenile populations to determine migration time and size at time of migration for juvenile fall chinook and chum rearing below Bonneville Dam. We will coded-wire tag juvenile fall chinook below Bonneville Dam to determine juvenile to adult survival rate and ocean distribution.

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APPENDIX A

Chum carcass tagging methodology.

The theory is described in Schwarz, C.J. and Arnason, A.N. (1996). A general methodology for the analysis of capture-recapture experiments in open populations. Biometrics, 52, 860-873

Input file passed to CARLAN

```
!Example:   Ives Chum 2003 carc tagging
!           p(i) changes over time
!           phi(i) changes over time
!           births(i) change over time.
!
!    This will use the model keywords to fit the model
!
Ives Chum Band.year = 2003.03 Sighting year=03. p(t), phi(t), b(t) - model keywords
1 5 notrace stat mod design noinit
1     38     0     12     6     0
2     63     5     26     14    1
3     112    10    34     8     5
4     129    12    38     4     1
5     40     5     8      0     0

 t t t          Note the way the model keywords are used
0                    Note that 0 beta terms, but 1 column appears below to fix parameters
1  10   p(1) = 1     Note that you must know the internals to be able to fix this without using a PIM
5  10   p(5) = 1
0 0 0 0 0 0 0     end of design matrix specification
```

Results returned from CARLAN

```
1


 Popan 7 Version June 2002:  Ives Chum Band.year = 2003.03 Sighting year=03. p(t), phi(t), b(t) - model keywords

 Trace flags:TFFFFFFFFF FFFFFFFFFF FFFFFFFFFF FFFFFFFFFF

 Summary.Statistics
 grp    t(i)    n(i)    m(i)    u(i)    RR(i)   r(i)   z(i)   TT(i)
   1    1.0     38.0    0.0     38.0    12.0    6.0    0.0    0.0
   1    2.0     63.0    5.0     58.0    26.0    14.0   1.0    6.0
   1    3.0    112.0    10.0   102.0    34.0    8.0    5.0    15.0
   1    4.0    129.0    12.0   117.0    38.0    4.0    1.0    13.0
   1    5.0     40.0    5.0     35.0    8.0     0.0    0.0    5.0
 End of Statistics
       ***** Warning ***** No marked animals captured in group   1;  at index   1; time index=  1.0
       ***** Warning ***** No animals seen before and after in group   1; at index 1: time index=  1.0
```

***** Warning ***** No animals seen before and after in group 1; at index 5: time index= 5.0

Model specified: p:t phi:t pent:t

Transform : p:logit phi:logit pent:logit

Parmeter Index Matrix in standard format

1	p	1	2	3	4	5
1	phi	6	7	8	9	
1	pent	10	11	12	13	14

Fully specified design matrix including N parameters (which don't appear in PIM)

Std PIM	User PIM	Trans	Beta parameter number 1	2	3	4	5	6	7	8	9	10	11	12	13	
1	1	logit	10.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
2	2	logit	0.0	1.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
3	3	logit	0.0	0.0	1.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
4	4	logit	0.0	0.0	0.0	1.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
5	5	logit	10.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
6	6	logit	0.0	0.0	0.0	0.0	1.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
7	7	logit	0.0	0.0	0.0	0.0	0.0	1.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
8	8	logit	0.0	0.0	0.0	0.0	0.0	0.0	1.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
9	9	logit	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.0	0.0	0.0	0.0	0.0	0.0	0.0
10	10	logit	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.0	0.0	0.0	0.0	0.0	0.0
11	11	logit	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.0	0.0	0.0	0.0	0.0
12	12	logit	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.0	0.0	0.0	0.0
13	13	logit	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.0	0.0	0.0
14	14	logit	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.0	0.0
15	0	ident	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.0

Initial values specified by user in standard order
Values of -1 indicate user did not specify any inital value

1	p	-1.000	-1.000	-1.000	-1.000	-1.000
1	phi	-1.000	-1.000	-1.000	-1.000	
1	pent	-1.000	-1.000	-1.000	-1.000	-1.000

1

Ives Chum Band.year = 2003.03 Sighting year=03. p(t), phi(t), b(t) - model keywords

P(t); PHI(t); ENTRY(t)

Initial Estimates

group	t(i)	pc(i)	phi(i)	pent(i)
1	0.0			0.107
1	1.0	1.000	0.571	0.077
1	2.0	0.729	0.980	0.485
1	3.0	0.320	0.389	0.204
1	4.0	0.558	0.105	0.126
1	5.0	1.000		

Cycle 0; Iteration 0; Stage Init est ; Cond.log.like -51.692; lamba
Cycle 1; Iteration 1; Stage find pc ; Cond.log.like -46.207; lamba 0.000100
Cycle 1; Iteration 2; Stage find pc ; Cond.log.like -43.217; lamba 0.000010
Cycle 1; Iteration 3; Stage find pc ; Cond.log.like -41.478; lamba 0.000001
Cycle 1; Iteration 4; Stage find pc ; Cond.log.like -40.439; lamba 0.000000
Cycle 1; Iteration 5; Stage find pc ; Cond.log.like -39.808; lamba 0.000000
Cycle 1; Iteration 6; Stage find pc ; Cond.log.like -39.421; lamba 0.000000
Cycle 1; Iteration 7; Stage find pc ; Cond.log.like -39.180; lamba 0.000000
Cycle 1; Iteration 8; Stage find pc ; Cond.log.like -39.027; lamba 0.000000
Cycle 1; Iteration 9; Stage find pc ; Cond.log.like -38.927; lamba 0.000000
Cycle 1; Iteration 10; Stage find pc ; Cond.log.like -38.860; lamba 0.000000
Cycle 1; Iteration 1; Stage find phi ; Cond.log.like -38.665; lamba 0.000100
Cycle 1; Iteration 2; Stage find phi ; Cond.log.like -38.636; lamba 0.000010
Cycle 1; Iteration 3; Stage find phi ; Cond.log.like -38.621; lamba 0.000001
Cycle 1; Iteration 4; Stage find phi ; Cond.log.like -38.612; lamba 0.000000
Cycle 1; Iteration 5; Stage find phi ; Cond.log.like -38.605; lamba 0.000000
Cycle 1; Iteration 6; Stage find phi ; Cond.log.like -38.600; lamba 0.000000
Cycle 1; Iteration 7; Stage find phi ; Cond.log.like -38.596; lamba 0.000000
Renormalization of the pents was required. Sum of pents was 1.031
Cycle 1; Iteration 1; Stage find pent ; Cond.log.like -24.152; lamba 0.000100

Cycle 1; Iteration 2; Stage find pent ; Cond.log.like -23.430; lamba 0.000010
Cycle 1; Iteration 3; Stage find pent ; Cond.log.like -23.403; lamba 0.000001
Cycle 1; Iteration 4; Stage find pent ; Cond.log.like -23.402; lamba 0.000000
Cycle 2; Iteration 1; Stage find pc ; Cond.log.like -23.063; lamba 0.000100
Cycle 2; Iteration 2; Stage find pc ; Cond.log.like -22.845; lamba 0.000010
Cycle 2; Iteration 3; Stage find pc ; Cond.log.like -22.691; lamba 0.000001
Cycle 2; Iteration 4; Stage find pc ; Cond.log.like -22.579; lamba 0.000000
Cycle 2; Iteration 5; Stage find pc ; Cond.log.like -22.496; lamba 0.000000
Cycle 2; Iteration 6; Stage find pc ; Cond.log.like -22.434; lamba 0.000000
Cycle 2; Iteration 7; Stage find pc ; Cond.log.like -22.386; lamba 0.000000
Cycle 2; Iteration 8; Stage find pc ; Cond.log.like -22.350; lamba 0.000000
Cycle 2; Iteration 9; Stage find pc ; Cond.log.like -22.323; lamba 0.000000
Cycle 2; Iteration 10; Stage find pc ; Cond.log.like -22.302; lamba 0.000000
Cycle 2; Iteration 1; Stage find phi ; Cond.log.like -22.224; lamba 0.000100
Cycle 2; Iteration 2; Stage find phi ; Cond.log.like -22.209; lamba 0.000010
Cycle 2; Iteration 3; Stage find phi ; Cond.log.like -22.203; lamba 0.000001
Cycle 2; Iteration 4; Stage find phi ; Cond.log.like -22.201; lamba 0.000000
Cycle 2; Iteration 1; Stage find pent ; Cond.log.like -21.975; lamba 0.000100
Cycle 2; Iteration 2; Stage find pent ; Cond.log.like -21.970; lamba 0.000010
Cycle 2; Iteration 3; Stage find pent ; Cond.log.like -21.969; lamba 0.000001
Cycle 3; Iteration 1; Stage find pc ; Cond.log.like -21.909; lamba 0.000100
Cycle 3; Iteration 2; Stage find pc ; Cond.log.like -21.864; lamba 0.000010
Cycle 3; Iteration 3; Stage find pc ; Cond.log.like -21.830; lamba 0.000001
Cycle 3; Iteration 4; Stage find pc ; Cond.log.like -21.804; lamba 0.000000

Cycle 3; Iteration 5; Stage find pc ; Cond.log.like -21.784; lamba 0.000000
Cycle 3; Iteration 6; Stage find pc ; Cond.log.like -21.769; lamba 0.000000
Cycle 3; Iteration 7; Stage find pc ; Cond.log.like -21.757; lamba 0.000000
Cycle 3; Iteration 8; Stage find pc ; Cond.log.like -21.749; lamba 0.000000
Cycle 3; Iteration 9; Stage find pc ; Cond.log.like -21.742; lamba 0.000000
Cycle 3; Iteration 10; Stage find pc ; Cond.log.like -21.737; lamba 0.000000
Cycle 3; Iteration 1; Stage find phi ; Cond.log.like -21.731; lamba 0.000100
Cycle 3; Iteration 2; Stage find phi ; Cond.log.like -21.730; lamba 0.000010
Cycle 3; Iteration 1; Stage find pent ; Cond.log.like -21.664; lamba 0.000100
Cycle 3; Iteration 2; Stage find pent ; Cond.log.like -21.663; lamba 0.000010
Cycle 4; Iteration 1; Stage find pc ; Cond.log.like -21.640; lamba 0.000100
Cycle 4; Iteration 2; Stage find pc ; Cond.log.like -21.623; lamba 0.000010
Cycle 4; Iteration 3; Stage find pc ; Cond.log.like -21.610; lamba 0.000001
Cycle 4; Iteration 4; Stage find pc ; Cond.log.like -21.600; lamba 0.000000
Cycle 4; Iteration 5; Stage find pc ; Cond.log.like -21.593; lamba 0.000000
Cycle 4; Iteration 6; Stage find pc ; Cond.log.like -21.587; lamba 0.000000
Cycle 4; Iteration 7; Stage find pc ; Cond.log.like -21.583; lamba 0.000000
Cycle 4; Iteration 1; Stage find phi ; Cond.log.like -21.580; lamba 0.000100
Cycle 4; Iteration 1; Stage find pent ; Cond.log.like -21.559; lamba 0.000100
Cycle 4; Iteration 2; Stage find pent ; Cond.log.like -21.558; lamba 0.000010
Cycle 5; Iteration 1; Stage find pc ; Cond.log.like -21.546; lamba 0.000100
Cycle 5; Iteration 2; Stage find pc ; Cond.log.like -21.537; lamba 0.000010
Cycle 5; Iteration 3; Stage find pc ; Cond.log.like -21.530; lamba 0.000001
Cycle 5; Iteration 4; Stage find pc ; Cond.log.like -21.525; lamba 0.000000

Cycle 5; Iteration 5; Stage find pc ; Cond.log.like -21.521; lamba 0.000000
Cycle 5; Iteration 1; Stage find phi ; Cond.log.like -21.519; lamba 0.000100
Cycle 5; Iteration 1; Stage find pent ; Cond.log.like -21.510; lamba 0.000100
Cycle 5; Iteration 2; Stage find pent ; Cond.log.like -21.510; lamba 0.000010
Cycle 6; Iteration 1; Stage find pc ; Cond.log.like -21.502; lamba 0.000100
Cycle 6; Iteration 2; Stage find pc ; Cond.log.like -21.496; lamba 0.000010
Cycle 6; Iteration 3; Stage find pc ; Cond.log.like -21.492; lamba 0.000001
Cycle 6; Iteration 1; Stage find phi ; Cond.log.like -21.489; lamba 0.000100
Cycle 6; Iteration 1; Stage find pent ; Cond.log.like -21.486; lamba 0.000100
Cycle 7; Iteration 1; Stage find pc ; Cond.log.like -21.481; lamba 0.000100
Cycle 7; Iteration 2; Stage find pc ; Cond.log.like -21.477; lamba 0.000010
Cycle 7; Iteration 1; Stage find phi ; Cond.log.like -21.475; lamba 0.000100
Cycle 7; Iteration 1; Stage find pent ; Cond.log.like -21.473; lamba 0.000100
Cycle 8; Iteration 1; Stage find pc ; Cond.log.like -21.468; lamba 0.000100
Cycle 8; Iteration 1; Stage find phi ; Cond.log.like -21.466; lamba 0.000100
Cycle 8; Iteration 1; Stage find pent ; Cond.log.like -21.466; lamba 0.000100
Cycle 9; Iteration 1; Stage find pc ; Cond.log.like -21.461; lamba 0.000100
Cycle 9; Iteration 1; Stage find phi ; Cond.log.like -21.459; lamba 0.000100
Cycle 9; Iteration 1; Stage find pent ; Cond.log.like -21.459; lamba 0.000100
Cycle 10; Iteration 1; Stage find pc ; Cond.log.like -21.454; lamba 0.000100
Cycle 10; Iteration 1; Stage find phi ; Cond.log.like -21.453; lamba 0.000100
Cycle 10; Iteration 1; Stage find pent ; Cond.log.like -21.453; lamba 0.000100
Cycle 11; Iteration 1; Stage find pc ; Cond.log.like -21.449; lamba 0.000100
Cycle 11; Iteration 1; Stage find phi ; Cond.log.like -21.447; lamba 0.000100

Cycle 11; Iteration 1; Stage find pent ; Cond.log.like -21.447; lamba 0.000100
Cycle 12; Iteration 1; Stage find pc ; Cond.log.like -21.443; lamba 0.000100
Cycle 12; Iteration 1; Stage find phi ; Cond.log.like -21.442; lamba 0.000100
Cycle 12; Iteration 1; Stage find pent ; Cond.log.like -21.441; lamba 0.000100
Cycle 13; Iteration 1; Stage find pc ; Cond.log.like -21.438; lamba 0.000100
Cycle 13; Iteration 1; Stage find phi ; Cond.log.like -21.437; lamba 0.000100
Cycle 13; Iteration 1; Stage find pent ; Cond.log.like -21.436; lamba 0.000100
Cycle 14; Iteration 1; Stage find pc ; Cond.log.like -21.433; lamba 0.000100
Cycle 14; Iteration 1; Stage find phi ; Cond.log.like -21.432; lamba 0.000100
Cycle 14; Iteration 1; Stage find pent ; Cond.log.like -21.431; lamba 0.000100
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Cycle 15; Iteration 3; Stage find all ; Cond.log.like -21.419; lamba 0.000000
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Cycle 15; Iteration 186; Stage find all ; Cond.log.like -21.314; lamba 0.000000
Cycle 15; Iteration 187; Stage find all ; Cond.log.like -21.314; lamba 0.000000
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Final.estimates
Ives Chum Band.year = 2003.03 Sighting year=03. p(t), phi(t), b(t) - model keywords
P(t); PHI(t); ENTRY(t)

Model.fitting: 1 5 -21.314 12 1 0 -21.251
(Groups, samples, cond.log-likelihood, nbeta, restrictions, singular values, saturated log-likelihood)

Estimates.of.parameters

Beta parameter estimates and estimated standard errors

Beta 1 0.95074 -0.58860 0.31963 0.31323 8.14387 -0.40262 -2.12397 -2.57306 -1.73444 -0.03418
se 1.11158 0.64123 1.17133 0.753161131.56689 0.86263 0.52524 0.26083 0.44769 0.65498

Beta 11 -1.15681 -2.97899
se 0.83087 0.57819

Standard parameter estimates

group	t(i)	pc(i)	se	phi(i)	se	pent(i)	se
1	0.0				0.071	0.017	
1	1.0	1.000	0.000	0.578	0.184	0.150	0.057
1	2.0	0.721	0.223	1.000	0.329	0.491	0.164
1	3.0	0.357	0.147	0.401	0.207	0.239	0.151
1	4.0	0.579	0.285	0.107	0.050	0.048	0.027
1	5.0	1.000	0.000			536.1	99.3

Derived estimates

group	t(i)	avg-B(i)	se|N-tot	avg-N(i)	se|N-tot	avg-B*(i)	se|N-tot	gamma(i)	se|N-tot	lambda(i)	se|N-tot
1	0.0	38.0	5.9			38.0	5.9				
1	1.0	80.4	26.8	38.0	5.9	104.5	32.3	0.000	0.000	7.278	4.109
1	2.0	263.4	117.7	87.4	27.8	263.5	90.6	0.079	0.046	6.232	4.262
1	3.0	128.2	82.5	313.8	127.6	195.7	102.0	0.160	0.092	0.945	0.692
1	4.0	25.9	11.4	222.7	109.5	65.0	30.2	0.424	0.204	0.304	0.257
1	5.0			40.0	6**.0**	**666.6**	**83.0**	0.352	0.267		
total potential breeders						2237.2	1179.4				
AUC estimate						688.1	84.0				
stream residence estimate						0.828	0.119				
lady estimate						1.887	0.584				

Breeding proportion estimates

group	t(i)	breed(i)	se|N-tot	breed(i)-P	se|N-tot
1	0.0	3.044	0.140	4.473	0.396
1	1.0	0.071	0.017	0.002	0.002
1	2.0	0.150	0.057	0.022	0.021
1	3.0	0.491	0.164	0.125	0.108
1	4.0	0.239	0.151	0.202	0.179
1	5.0	0.048	0.027	0.648	0.267

APPENDIX B

Chinook carcass tagging methodology.

Jolly-Seber Analysis of Open Populations for Multiple Groups.

The theory is described in
Schwarz, C.J. and Arnason, A.N. (1996). A general methodology for the analysis of capture-recapture experiments in open populations. Biometrics, 52, 860-873

Input file passed to CARLAN

```
!Example:   Ives Fall Chinook 2003 carc tagging
!           p(i) changes over time
!           phi(i) changes over time
!           births(i) change over time.
!
!     This will use the model keywords to fit the model
!
Ives FallChinook Band.year = 2003.03 Sighting year=03. p(t), phi(t), b(t) - model keywords
1 8 notrace stat mod design noinit
1    2    0    1    1    0
2    24   1    17   10   0
3    125  6    60   20   4
4    286  17   269  154  7
5    278  90   186  110  71
6    375  160  181  104  21
7    185  110  62   13   15
8    49   28   10   0    0
 t t t        Note the way the model keywords are used
0                 Note that 0 beta terms, but 1 column appears below to fix parameters
1  10   p(1) = 1      Note that you must know the internals to be able to fix this without using a PIM
8  10   p(8) = 1
0 0 0 0 0 0 0      end of design matrix specification
```

Results returned from CARLAN

1

Popan 7 Version June 2002: Ives FallChinook Band.year = 2003.03 Sighting year=03. p(t), phi(t), b(t) - model keywords

Trace flags:TFFFFFFFFF FFFFFFFFFF FFFFFFFFFF FFFFFFFFFF

Summary.Statistics

grp	t(i)	n(i)	m(i)	u(i)	RR(i)	r(i)	z(i)	TT(i)
1	1.0	2.0	0.0	2.0	1.0	1.0	0.0	0.0
1	2.0	24.0	1.0	23.0	17.0	10.0	0.0	1.0
1	3.0	125.0	6.0	119.0	60.0	20.0	4.0	10.0
1	4.0	286.0	17.0	269.0	269.0	154.0	7.0	24.0
1	5.0	278.0	90.0	188.0	186.0	110.0	71.0	161.0
1	6.0	375.0	160.0	215.0	181.0	104.0	21.0	181.0
1	7.0	185.0	110.0	75.0	62.0	13.0	15.0	125.0
1	8.0	49.0	28.0	21.0	10.0	0.0	0.0	28.0

End of Statistics

***** Warning ***** No marked animals captured in group 1; at index 1; time index= 1.0

***** Warning ***** No animals seen before and after in group 1; at index 1: time index= 1.0

***** Warning ***** No animals seen before and after in group 1; at index 2: time index= 2.0

***** Warning ***** No animals seen before and after in group 1; at index 8: time index= 8.0

Model specified: p:t phi:t pent:t

Transform : p:logit phi:logit pent:logit

Parmeter Index Matrix in standard format

```
  1    p       1   2   3   4   5   6   7   8
  1   phi       9  10  11  12  13  14  15
  1  pent   16  17  18  19  20  21  22  23
```

Fully specified design matrix including N parameters (which don't appear in PIM)

```
   Std  User Trans     Beta parameter number
   PIM  PIM                    1    2    3    4    5    6    7    8    9   10   11   12   13   14
15   16   17   18   19   20
                             21   22
     1    1  logit      10.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0
0.0  0.0  0.0  0.0  0.0  0.0  0.0
                            0.0  0.0
     2    2  logit       0.0  1.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0
0.0  0.0  0.0  0.0  0.0  0.0  0.0
```

0.0 0.0
3 3 logit 0.0 0.0 1.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0
0.0 0.0 0.0 0.0 0.0 0.0 0.0
0.0 0.0
4 4 logit 0.0 0.0 0.0 1.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0
0.0 0.0 0.0 0.0 0.0 0.0 0.0
0.0 0.0
5 5 logit 0.0 0.0 0.0 0.0 1.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0
0.0 0.0 0.0 0.0 0.0 0.0 0.0
0.0 0.0
6 6 logit 0.0 0.0 0.0 0.0 0.0 1.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0
0.0 0.0 0.0 0.0 0.0 0.0 0.0
0.0 0.0
7 7 logit 0.0 0.0 0.0 0.0 0.0 0.0 1.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0
0.0 0.0 0.0 0.0 0.0 0.0 0.0
0.0 0.0
8 8 logit 10.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0
0.0 0.0 0.0 0.0 0.0 0.0 0.0
0.0 0.0
9 9 logit 0.0 0.0 0.0 0.0 0.0 0.0 0.0 1.0 0.0 0.0 0.0 0.0 0.0 0.0
0.0 0.0 0.0 0.0 0.0 0.0 0.0
0.0 0.0
10 10 logit 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 1.0 0.0 0.0 0.0 0.0 0.0
0.0 0.0 0.0 0.0 0.0 0.0 0.0
0.0 0.0
11 11 logit 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 1.0 0.0 0.0 0.0 0.0
0.0 0.0 0.0 0.0 0.0 0.0 0.0
0.0 0.0
12 12 logit 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 1.0 0.0 0.0 0.0
0.0 0.0 0.0 0.0 0.0 0.0 0.0
0.0 0.0
13 13 logit 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 1.0 0.0 0.0
0.0 0.0 0.0 0.0 0.0 0.0 0.0
0.0 0.0
14 14 logit 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 1.0 0.0
0.0 0.0 0.0 0.0 0.0 0.0 0.0
0.0 0.0
15 15 logit 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 1.0
0.0 0.0 0.0 0.0 0.0 0.0 0.0
0.0 0.0
16 16 logit 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0
1.0 0.0 0.0 0.0 0.0 0.0 0.0
0.0 0.0
17 17 logit 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0
0.0 1.0 0.0 0.0 0.0 0.0 0.0
0.0 0.0
18 18 logit 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0
0.0 0.0 1.0 0.0 0.0 0.0 0.0
0.0 0.0

19 19 logit 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0
0.0 0.0 0.0 1.0 0.0 0.0 0.0
0.0 0.0
20 20 logit 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0
0.0 0.0 0.0 0.0 1.0 0.0 0.0
0.0 0.0
21 21 logit 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0
0.0 0.0 0.0 0.0 0.0 1.0 0.0
0.0 0.0
22 22 logit 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0
0.0 0.0 0.0 0.0 0.0 0.0 1.0
0.0 0.0
23 23 logit 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0
0.0 0.0 0.0 0.0 0.0 0.0 0.0
1.0 0.0
24 0 ident 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0
0.0 0.0 0.0 0.0 0.0 0.0 0.0
0.0 1.0

Initial values specified by user in standard order
Values of -1 indicate user did not specify any inital value

1 p -1.000 -1.000 -1.000 -1.000 -1.000 -1.000 -1.000 -1.000
1 phi -1.000 -1.000 -1.000 -1.000 -1.000 -1.000 -1.000
1 pent -1.000 -1.000 -1.000 -1.000 -1.000 -1.000 -1.000 -1.000
1

Ives FallChinook Band.year = 2003.03 Sighting year=03. p(t), phi(t), b(t) - model keywords
P(t); PHI(t); ENTRY(t)

Initial Estimates

group	t(i)	pc(i)	phi(i)	pent(i)
1	0.0			0.003
1	1.0	1.000	0.980	0.018
1	2.0	0.950	0.980	0.283
1	3.0	0.333	0.406	0.291
1	4.0	0.582	0.747	0.234
1	5.0	0.428	0.642	0.082
1	6.0	0.814	0.834	0.066
1	7.0	0.606	0.210	0.023
1	8.0	1.000		

Cycle 0; Iteration 0; Stage Init est ; Cond.log.like -49.994; lamba
Cycle 1; Iteration 1; Stage find pc ; Cond.log.like -49.780; lamba 0.000100

Cycle 1; Iteration 2; Stage find pc ; Cond.log.like -49.685; lamba 0.000010
Cycle 1; Iteration 3; Stage find pc ; Cond.log.like -49.634; lamba 0.000001
Cycle 1; Iteration 4; Stage find pc ; Cond.log.like -49.604; lamba 0.000000
Cycle 1; Iteration 5; Stage find pc ; Cond.log.like -49.585; lamba 0.000000
Cycle 1; Iteration 6; Stage find pc ; Cond.log.like -49.573; lamba 0.000000
Cycle 1; Iteration 7; Stage find pc ; Cond.log.like -49.563; lamba 0.000000
Cycle 1; Iteration 8; Stage find pc ; Cond.log.like -49.556; lamba 0.000000
Cycle 1; Iteration 9; Stage find pc ; Cond.log.like -49.550; lamba 0.000000
Cycle 1; Iteration 10; Stage find pc ; Cond.log.like -49.545; lamba 0.000000
Cycle 1; Iteration 1; Stage find phi ; Cond.log.like -49.353; lamba 0.000100
Cycle 1; Iteration 2; Stage find phi ; Cond.log.like -49.330; lamba 0.000010
Cycle 1; Iteration 3; Stage find phi ; Cond.log.like -49.319; lamba 0.000001
Cycle 1; Iteration 4; Stage find phi ; Cond.log.like -49.312; lamba 0.000000
Cycle 1; Iteration 5; Stage find phi ; Cond.log.like -49.307; lamba 0.000000
Cycle 1; Iteration 1; Stage find pent ; Cond.log.like -45.435; lamba 0.000100
Cycle 1; Iteration 2; Stage find pent ; Cond.log.like -44.838; lamba 0.000010
Cycle 1; Iteration 3; Stage find pent ; Cond.log.like -44.736; lamba 0.000001
Cycle 1; Iteration 4; Stage find pent ; Cond.log.like -44.714; lamba 0.000000
Cycle 1; Iteration 5; Stage find pent ; Cond.log.like -44.708; lamba 0.000000
Cycle 1; Iteration 6; Stage find pent ; Cond.log.like -44.706; lamba 0.000000
Cycle 2; Iteration 1; Stage find pc ; Cond.log.like -44.583; lamba 0.000100
Cycle 2; Iteration 2; Stage find pc ; Cond.log.like -44.529; lamba 0.000010
Cycle 2; Iteration 3; Stage find pc ; Cond.log.like -44.504; lamba 0.000001
Cycle 2; Iteration 4; Stage find pc ; Cond.log.like -44.492; lamba 0.000000

Cycle 2; Iteration 5; Stage find pc ; Cond.log.like -44.485; lamba 0.000000
Cycle 2; Iteration 6; Stage find pc ; Cond.log.like -44.482; lamba 0.000000
Cycle 2; Iteration 1; Stage find phi ; Cond.log.like -44.373; lamba 0.000100
Cycle 2; Iteration 2; Stage find phi ; Cond.log.like -44.369; lamba 0.000010
Cycle 2; Iteration 1; Stage find pent ; Cond.log.like -44.321; lamba 0.000100
Cycle 2; Iteration 2; Stage find pent ; Cond.log.like -44.312; lamba 0.000010
Cycle 2; Iteration 3; Stage find pent ; Cond.log.like -44.309; lamba 0.000001
Cycle 3; Iteration 1; Stage find pc ; Cond.log.like -44.307; lamba 0.000100
Cycle 3; Iteration 1; Stage find phi ; Cond.log.like -44.300; lamba 0.000100
Cycle 3; Iteration 2; Stage find phi ; Cond.log.like -44.298; lamba 0.000010
Cycle 3; Iteration 1; Stage find pent ; Cond.log.like -44.296; lamba 0.000100
Cycle 4; Iteration 1; Stage find pc ; Cond.log.like -44.294; lamba 0.000100
Cycle 4; Iteration 1; Stage find phi ; Cond.log.like -44.293; lamba 0.000100
Cycle 4; Iteration 1; Stage find pent ; Cond.log.like -44.292; lamba 0.000100
Cycle 5; Iteration 1; Stage find all ; Cond.log.like -44.290; lamba 0.000000
Cycle 5; Iteration 2; Stage find all ; Cond.log.like -44.288; lamba 0.000000
Cycle 5; Iteration 3; Stage find all ; Cond.log.like -44.286; lamba 0.000000
Cycle 5; Iteration 4; Stage find all ; Cond.log.like -44.285; lamba 0.000000
Cycle 5; Iteration 5; Stage find all ; Cond.log.like -44.284; lamba 0.000000
Cycle 5; Iteration 6; Stage find all ; Cond.log.like -44.282; lamba 0.000000
Cycle 5; Iteration 7; Stage find all ; Cond.log.like -44.281; lamba 0.000000
Cycle 5; Iteration 8; Stage find all ; Cond.log.like -44.280; lamba 0.000000
Cycle 5; Iteration 9; Stage find all ; Cond.log.like -44.279; lamba 0.000000
Cycle 5; Iteration 10; Stage find all ; Cond.log.like -44.278; lamba 0.000000

Cycle 5; Iteration 11; Stage find all ; Cond.log.like -44.277; lamba 0.000000
Cycle 5; Iteration 12; Stage find all ; Cond.log.like -44.277; lamba 0.000000
Cycle 5; Iteration 13; Stage find all ; Cond.log.like -44.276; lamba 0.000000
Cycle 5; Iteration 14; Stage find all ; Cond.log.like -44.275; lamba 0.000000
Cycle 5; Iteration 15; Stage find all ; Cond.log.like -44.274; lamba 0.000000
Cycle 5; Iteration 16; Stage find all ; Cond.log.like -44.274; lamba 0.000000
Cycle 5; Iteration 17; Stage find all ; Cond.log.like -44.273; lamba 0.000000
Cycle 5; Iteration 18; Stage find all ; Cond.log.like -44.272; lamba 0.000000
Cycle 5; Iteration 19; Stage find all ; Cond.log.like -44.272; lamba 0.000000
Cycle 5; Iteration 20; Stage find all ; Cond.log.like -44.271; lamba 0.000000
Cycle 5; Iteration 21; Stage find all ; Cond.log.like -44.271; lamba 0.000000
Cycle 5; Iteration 22; Stage find all ; Cond.log.like -44.270; lamba 0.000000
Cycle 5; Iteration 23; Stage find all ; Cond.log.like -44.270; lamba 0.000000
Cycle 5; Iteration 24; Stage find all ; Cond.log.like -44.269; lamba 0.000000
Cycle 5; Iteration 25; Stage find all ; Cond.log.like -44.269; lamba 0.000000
Cycle 5; Iteration 26; Stage find all ; Cond.log.like -44.269; lamba 0.000000
Cycle 5; Iteration 27; Stage find all ; Cond.log.like -44.268; lamba 0.000000
Cycle 5; Iteration 28; Stage find all ; Cond.log.like -44.268; lamba 0.000000
Cycle 5; Iteration 29; Stage find all ; Cond.log.like -44.267; lamba 0.000000
Cycle 5; Iteration 30; Stage find all ; Cond.log.like -44.267; lamba 0.000000
Cycle 5; Iteration 31; Stage find all ; Cond.log.like -44.267; lamba 0.000000
Cycle 5; Iteration 32; Stage find all ; Cond.log.like -44.267; lamba 0.000000
Cycle 5; Iteration 33; Stage find all ; Cond.log.like -44.266; lamba 0.000000
Cycle 5; Iteration 34; Stage find all ; Cond.log.like -44.266; lamba 0.000000

Cycle 5; Iteration 35; Stage find all ; Cond.log.like -44.266; lamba 0.000000
Cycle 5; Iteration 36; Stage find all ; Cond.log.like -44.265; lamba 0.000000
Cycle 5; Iteration 37; Stage find all ; Cond.log.like -44.265; lamba 0.000000
Cycle 5; Iteration 38; Stage find all ; Cond.log.like -44.265; lamba 0.000000
Cycle 5; Iteration 39; Stage find all ; Cond.log.like -44.265; lamba 0.000000
Cycle 5; Iteration 40; Stage find all ; Cond.log.like -44.265; lamba 0.000000
Cycle 5; Iteration 41; Stage find all ; Cond.log.like -44.264; lamba 0.000000
Cycle 5; Iteration 42; Stage find all ; Cond.log.like -44.264; lamba 0.000000
Cycle 5; Iteration 43; Stage find all ; Cond.log.like -44.264; lamba 0.000000
Cycle 5; Iteration 44; Stage find all ; Cond.log.like -44.264; lamba 0.000000
Cycle 5; Iteration 45; Stage find all ; Cond.log.like -44.264; lamba 0.000000
Cycle 5; Iteration 46; Stage find all ; Cond.log.like -44.263; lamba 0.000000
Cycle 5; Iteration 47; Stage find all ; Cond.log.like -44.263; lamba 0.000000
Cycle 5; Iteration 48; Stage find all ; Cond.log.like -44.263; lamba 0.000000
Cycle 5; Iteration 49; Stage find all ; Cond.log.like -44.263; lamba 0.000000
Cycle 5; Iteration 50; Stage find all ; Cond.log.like -44.263; lamba 0.000000
Cycle 5; Iteration 51; Stage find all ; Cond.log.like -44.263; lamba 0.000000
Cycle 5; Iteration 52; Stage find all ; Cond.log.like -44.263; lamba 0.000000
Cycle 5; Iteration 53; Stage find all ; Cond.log.like -44.263; lamba 0.000000
Cycle 5; Iteration 54; Stage find all ; Cond.log.like -44.262; lamba 0.000000
Cycle 5; Iteration 55; Stage find all ; Cond.log.like -44.262; lamba 0.000000
Cycle 5; Iteration 56; Stage find all ; Cond.log.like -44.262; lamba 0.000000
Cycle 5; Iteration 57; Stage find all ; Cond.log.like -44.262; lamba 0.000000
Cycle 5; Iteration 58; Stage find all ; Cond.log.like -44.262; lamba 0.000000

Cycle 5; Iteration 59; Stage find all ; Cond.log.like -44.262; lamba 0.000000
Cycle 5; Iteration 60; Stage find all ; Cond.log.like -44.262; lamba 0.000000
Cycle 5; Iteration 61; Stage find all ; Cond.log.like -44.262; lamba 0.000000
Cycle 5; Iteration 62; Stage find all ; Cond.log.like -44.262; lamba 0.000000
Cycle 5; Iteration 63; Stage find all ; Cond.log.like -44.262; lamba 0.000000
Cycle 5; Iteration 64; Stage find all ; Cond.log.like -44.261; lamba 0.000000
Cycle 5; Iteration 65; Stage find all ; Cond.log.like -44.261; lamba 0.000000
Cycle 5; Iteration 66; Stage find all ; Cond.log.like -44.261; lamba 0.000000
Cycle 5; Iteration 67; Stage find all ; Cond.log.like -44.261; lamba 0.000000
Cycle 5; Iteration 68; Stage find all ; Cond.log.like -44.261; lamba 0.000000
Cycle 5; Iteration 69; Stage find all ; Cond.log.like -44.261; lamba 0.000000
Cycle 5; Iteration 70; Stage find all ; Cond.log.like -44.261; lamba 0.000000
Cycle 5; Iteration 71; Stage find all ; Cond.log.like -44.261; lamba 0.000000
Cycle 5; Iteration 72; Stage find all ; Cond.log.like -44.261; lamba 0.000000
Cycle 5; Iteration 73; Stage find all ; Cond.log.like -44.261; lamba 0.000000
Cycle 5; Iteration 74; Stage find all ; Cond.log.like -44.261; lamba 0.000000
Cycle 5; Iteration 75; Stage find all ; Cond.log.like -44.261; lamba 0.000000
1

Final.estimates
Ives FallChinook Band.year = 2003.03 Sighting year=03. p(t), phi(t), b(t) - model keywords
P(t); PHI(t); ENTRY(t)

Model.fitting: 1 8 -44.261 21 1 0 -44.241
(Groups, samples, cond.log-likelihood, nbeta, restrictions, singular values, saturated log-likelihood)

Estimates.of.parameters

Beta parameter estimates and estimated standard errors

Beta 1 7.51955 -0.61945 0.33819 -0.28843 1.47625 0.43308
10.89091 8.24442 -0.35848 1.08283
se 42.96243 0.68442 0.45274 0.17004 0.24074 0.36950
0.000001133.73702 0.32379 0.26277

Beta 11 0.58497 1.61097 -1.32502 -6.41763 -3.95742 -0.95807 -
0.84110 -1.14757 -2.38991 -2.62768
se 0.17940 0.83154 0.31181 0.71248 0.22785 0.52285 0.46108
0.38366 0.38490 0.28557

Beta 21 -4.72511
se 0.52451

Standard parameter estimates

group	t(i)	pc(i)	se	phi(i)	se	pent(i)	se
1	0.0				0.002	0.001	
1	1.0	1.000	0.000	1.000	0.000	0.019	0.004
1	2.0	0.999	0.023	1.000	0.298	0.277	0.105
1	3.0	0.350	0.156	0.411	0.078	0.301	0.097
1	4.0	0.584	0.110	0.747	0.050	0.241	0.070
1	5.0	0.428	0.042	0.642	0.041	0.084	0.030
1	6.0	0.814	0.036	0.834	0.115	0.067	0.018
1	7.0	0.607	0.088	0.210	0.052	0.009	0.005
1	8.0	1.000	0.000			1227.1	101.1

Derived estimates

group	t(i)	avg-B(i)	se|N-tot	avg-N(i)	se|N-tot	avg-B*(i)	se|N-tot	gamma(i)	se|N-tot	lambda(i)	se|N-tot
1	0.0	2.0	1.4		2.0	1.4					
1	1.0	23.0	4.8	2.0	1.4	23.0	4.8	0.000	0.000	24.013	32.896
1	2.0	340.2	154.3	24.0	5.0	340.3	126.9	0.042	0.057	20.998	11.005
1	3.0	369.7	104.8	357.2	157.7	557.9	153.8	0.048	0.021	1.676	0.958
1	4.0	295.6	81.5	489.9	92.0	340.8	92.3	0.245	0.131	1.372	0.292
1	5.0	103.0	34.4	648.9	58.3	127.5	42.5	0.544	0.109	0.827	0.093

1	6.0	82.7	21.6	460.7	24.2	90.4	21.1	0.776	0.072	1.144	0.182
1	7.0	10.8	5.5	305.0	44.8	21.3	11.0	0.729	0.054	0.269	0.072
1	8.0		49.0	7.0	1503.3	90.9	0.780	0.109			

total potential breeders 3564.1 1028.1
AUC estimate 1533.4 94.1
stream residence estimate 1.348 0.095
lady estimate 3.580 0.975

Breeding proportion estimates

group	t(i)	breed(i)	se|N-tot	breed(i)-P	se|N-tot
1	0.0	4.326	0.169	5.908	0.294
1	1.0	0.002	0.001	0.000	0.000
1	2.0	0.019	0.004	0.003	0.001
1	3.0	0.277	0.105	0.056	0.031
1	4.0	0.301	0.097	0.181	0.058
1	5.0	0.241	0.070	0.201	0.062
1	6.0	0.084	0.030	0.127	0.046
1	7.0	0.067	0.018	0.211	0.057
1	8.0	0.009	0.005	0.220	0.109

APPENDIX C

Mean fork lengths of coho, cutthroat, steelhead and sockeye caught and sampled below Bonneville Dam, 2004.

Appendix Table C. Mean fork lengths of juvenile coho, cutthroat, steelhead and sockeye caught and sampled below Bonneville Dam, 2004.

	Coho	Cutthroat	Steelhead	Sockeye
Adipose fin clip				
Number	337	N/A	4	N/A
Mean Length	128.6	N/A	206.3	N/A
No adipose fin clip				
Number	465	4	8	1
Mean Length	62.5	185.3	169.5	123.0