BONNEVILLE POWER ADMINISTRATION

2005 Evaluation of Chum, Chinook and Coho Salmon Entrapment near Ives Island in the Columbia River

Annual Report 2004 - 2005 January 2006 DOE/BP-00004287-4

This Document should be cited as follows:

Wilson, Jeremy, Reed Duston, "2005 Evaluation of Chum, Chinook and Coho Salmon Entrapment near Ives Island in the Columbia River", 2004-2005 Annual Report, Project No. 199900301, 70 electronic pages, (BPA Report DOE/BP-00004287-4)

Bonneville Power Administration
P.O. Box 3621
Portland, OR 97208

This report was funded by the Bonneville Power Administration (BPA), U.S. Department of Energy, as part of BPA's program to protect, mitigate, and enhance fish and wildlife affected by the development and operation of hydroelectric facilities on the Columbia River and its tributaries. The views in this report are the author's and do not necessarily represent the views of BPA.

2005 EVALUATION OF CHUM, CHINOOK, AND COHO ENTRAPMENT NEAR IVES ISLAND IN THE COLUMBIA RIVER

Prepared by

Jeremy T. Wilson

and

Reed A. Duston

Pacific States Marine Fisheries Commission
2108 Grand Blvd
Vancouver, Washington 98661

Prepared for

Bonneville Power Administration
Environment Fish and Wildlife
P.O. Box 3621
Portland, Oregon 97208-3621

Project Number: 1999-003-01

Contract Numbers: BPA 00004287
PSMFC 528.05

During mid-1990s, Pacific States Marine Fisheries Commission (PSMFC) and Washington Department of Fish and Wildlife (WDFW) identified several populations of salmon spawning approximately three miles downstream of Bonneville Dam on the Columbia River. These populations are exposed to rapidly changing flow regimes associated with Bonneville Dam's operation. This study investigated the relationship between changing water levels and stranding or entrapment of juvenile salmon in the Ives Island area.

Walking surveys of the Ives Island and Pierce Island shorelines were conducted every one to three days throughout the juvenile emigration period. The nearby shorelines of the Washington and Oregon mainland were also surveyed.

Between January and June of 2005, surveyors examined 21 substantial entrapments and 20 stranding sites. A total of 14,337 salmonids, made up of three species, were found either entrapped or stranded. Nearly 92% of the salmonids were chinook salmon (*Oncorhynchus tshawytscha*), 4.5% were federally listed chum salmon (*Oncorhynchus keta*), and 3.8% were coho salmon (*Oncorhynchus kisutch*).

When compared to the 2004 study year, 2005 showed an 83% increase in the overall number of observed entrapped or stranded juvenile salmon. Much of this increase can be attributed to one entrapment found along the north shore of Pierce Island (identified as E501). E501 has historically been known to contain relatively large numbers of entrapped salmon. Even so, the number of entrapped salmon observed during 2005 was a 732% increase (5926) over any prior study years.

Over 83% of all chum, 63.1% of all chinook, and 63.2% of all coho sampled during 2005 were retrieved from entrapments that were likely to have formed when Bonneville Dam tailwater levels dropped to elevations between 11.5 and 12.9 feet.

Peak numbers of chum and chinook were sampled in mid-April when tailwater levels ranged between 11.6ft and 15.6ft. Peak numbers of coho were sampled during the last week of February, mid-March, and mid-April when tailwater level ranged between 11.4 and 14.3 feet, 11.5 and 15.3 ft, and 11.6 and 15.6 feet, respectively.

The fork length data indicate that the majority of the entrapped and stranded salmon are in the 35-50 mm range. Stranded members of all three salmon species had mean fork lengths that were 8% to 30% shorter than those of their entrapped counterparts.

The locations and habitat attributes of entrapments containing the majority of the observed juvenile salmon remain fairly constant from year to year. Changes in entrapment rankings appear to be more reflective of changes in prevailing tailwater levels than they are of changes in geography, vegetation, or fish behavior.

Data collected over the past six study years indicates that there are entrapments that are capable of entrapping large numbers of salmon as various tailwater levels. Avoiding specific tailwater ranges may not minimize the impact of juvenile stranding. The only way to substantially minimize the impact of stranding is to allow no tailwater fluctuations or to only allow a steady increase of the tailwater level throughout the juvenile emigration period.

TABLE OF CONTENTS

List of Figures

List of Tables

(Additional tables are in Appendix B)

Appendix A: Site Coordinates

Appendix B: Tables

INTRODUCTION

Historically, hundreds of thousands of salmon utilized spawning habitat in the mainstem of the Columbia River. Today, the majority of that historical spawning habitat has been inundated due to the development of a series of hydropower dams along the Columbia River. However, there are still isolated populations of salmon that are known to spawn in the Columbia River where habitat is available. One of these isolated populations is a substantial run of fall chinook that spawns in the Hanford Reach, a free-flowing stretch of the Columbia River lying between Priest Rapids and McNary Dams. A second area that supports both fall chinook and chum populations exists in the immediate vicinity of Ives Island, approximately three miles downstream of Bonneville Dam.

The identification of the Ives Island spawning grounds was based on the results of limited spawning ground surveys conducted between 1994-1997 by the Washington Department of Fish and Wildlife (WDFW) and Pacific States Marine Fisheries Commission (PSMFC). This discovery launched a large scale, multi-agency project to gain further population information, as well as investigate other potential mainstem Columbia River spawning areas. Today, the Ives Island area is the primary focus of the multi-agency project to identify genetic origin, estimate escapement size, production, juvenile to adult survival rates, emigration timing, and how hydropower operations effect habitat use in these populations.

The Ives Island population of chinook salmon is primarily made up of bright stock chinook, originating from strays from the Bonneville Hatchery propagation program. This stock of chinook is not included in the Lower Columbia River Chinook Evolutionary Significant Unit (ESU) that was federally listed as a threatened species under the Endangered Species Act (ESA) on March 24, 1999. However, limited numbers of tule stock fall chinook have also been observed spawning around Ives Island. This stock of chinook is included as part of the Lower Columbia River Chinook ESU that is federally protected under the ESA.

The National Marine Fisheries Service (NMFS) listed Columbia River Chum ESU as a threatened species under the ESA on March 25, 1999. The Columbia River Chum ESU consists of three distinct ecological zones, coastal, cascade, and gorge. Within these three ecological zones, there are sixteen historical populations that once yielded a cumulative annual return of approximately 283,421 chum salmon. Today, significant spawning occurs in two of these sixteen historical populations, Grays River and Lower Gorge Tributaries. The Ives Island population of chum is included as one of the subpopulations that make up the Lower Gorge Tributaries population (NMFS 2005).

Salmon populations spawning in close downstream proximity to hydropower facilities may be impacted by rapidly changing flow regimes (Nugent et al. 2001, Phinney 1974a and 1974b, Thompson 1970, Tipping et al. 1978). These highly variable flows can adversely impact these populations due to lack of access to prime spawning habitat, redd dewatering, and juvenile strandings.

Juvenile salmonids emerging around the Ives Island area utilize many shoreline habitats for rearing. Among these are shorelines surrounding Ives Island and Pierce Island, as well as along the Washington and Oregon shorelines. Many of these habitats are in relatively shallow water or are relatively large depressions in backwater areas that are connected to the river at certain flows. These intermittently suitable rearing habitats may become stranding and/or entrapment sites with a reduction in flow. Substantial numbers of entrapped and/or stranding fish may adversely effect the size of these locally spawning populations. This project examines the effects of hydropower operations on environmental conditions that may place juvenile salmon at risk through entrapment or stranding.

METHODS

Stranded fish are those salmon found out of the water. *Entrapped* salmon were fish found within pools of water no longer connected to the river. *Mortalities* are fish that were dead at the time of discovery. It may be assumed that all live stranded fish would have become mortalities within a very short period of time and may, in fact, have died after being returned to the river. It is also possible that entrapment mortalities were caused by dewatering at a time prior to sampling and would have been classified as stranding mortalities if the area had not re-flooded.

An attempt was made to survey the entire Ives Island study area every one to three days. These surveys consisted of walking the shorelines of Ives Island, Pierce Island, and the Washington and Oregon shoreline of the Columbia River while looking for entrapments sites and/or stranded fish.

The sampling area was broken into six distinct geographical areas, designated A-F. Area A covers the mouth of Hamilton Creek southeast to the middle of Ives Island, then westward to the channel break between Ives and Pierce Island. Area B covers the southwestern part of Ives Island across the channel break between the two islands to the southeastern tip of Pierce Island and borders Area A to its north. Area C starts at the eastern boundary of area B and covers the southern most shoreline of Pierce Island, then cuts to the northeast and follows the island's historical pre-dam shoreline until it reaches the border of area B. Area D borders area C to its east and Area E to its north then extends southwesterly and almost covers the entire west side of Pierce Island. Area E covers the northern shoreline of Pierce Island. Area F covers the Washington shoreline from just downstream of the mouth of Woodward Creek to just upstream of the mouth of Duncan Creek. Each area is shown below in Figure 1.

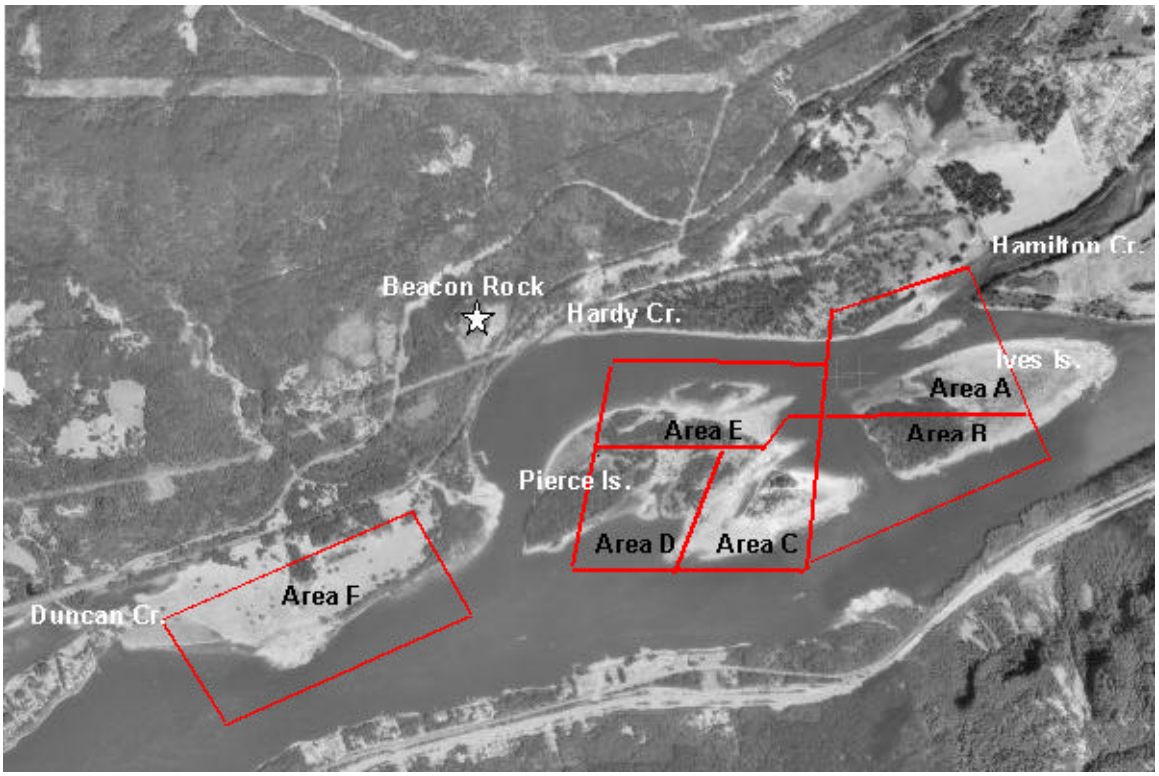

Figure 1: Sampling Area Sub Units (U.S.G.S. photograph taken 8/3/2000).

When a stranded salmon was discovered, the salmon was identified by species and measured. Visual estimates of substrate size and embeddedness, and vegetation densities at the stranding site were also recorded.

When an entrapment site was found, it was measured for size, depth, distance to the river, height above river, and temperature. Two entrapment temperatures were taken, one at the beginning of the sample and one at the end. Visual estimates of substrate size and embeddedness, and vegetation densities were also recorded.

An entrapment's height above the river refers to the difference in elevation between the surface of the river and what was perceived to be the low point in the crest of land between the river and the entrapment. In other words, the entrapment's height above the river identifies how much the river level would have to rise in order to reflood the entrapment. This data was used in conjunction with Bonneville tailwater measurements to determine each entrapment's critical tailwater range. This tailwater data was accessed via the NWP Water Management: Data Query web site (http://www.nwd-wc.usace.army.mil//cgi-bin/DataQuery).

To retrieve salmonids and other fishes from entrapment sites, the entrapment was stick seined, beach seined, or hand netted. If the entrapment contained salmon, they were anesthetized using MS-222, identified by species, measured, and enumerated, then, released back into the Columbia River. If an entrapment contained more than 100 hundred salmon of a given species, a sub-sample of 100 fish were measured.

If an entrapment's waters were replenished by fluctuating river levels on a later date and the entrapment once again contained salmon, it was re-sampled. Subsequent samples are identified by the entrapment's identifying code followed by -2, -3, etc. In the interest of covering as much of the study area as possible within the shortest period of time, some of the entrapment characteristics considered to be stable (i.e., substrata, maximum size, height above river) were not re-measured during subsequent visits.

River temperatures were taken once a day and air temperatures were taken once or twice a day depending on the weather and length of time spent sampling on a particular day. All strandings and entrapped locations were recorded using a Trimble Geo XT GPS Unit.

RESULTS

Seasonal Trends

Sampling began on January 10, 2005, and ended on June 20, 2005. Within this period, a total of 14,337 salmon were found either entrapped or stranded (Table 1).

Table 1. Total number of fish observed during the late winter through early summer sampling period (January 10 – June 20) near Ives Island in 2005.

Common Name	Scientific Name	Entrapped		Stranded		
		Mortality	Live	Mortality	Live	Total
Chinook Salmon	Oncorhynchus tshawytscha	5	13001	141	3	**13150**
Chum Salmon	Oncorhynchus keta	0	640	6	0	**646**
Coho Salmon	Oncorhynchus kisutch	0	515	26	0	**541**
Total		**5**	**14156**	**173**	**3**	**14337**

The first and last sampling dates on which threatened chum salmon were observed were February 21, 2005, and May 1, 2005, respectively. The weekly sampling results of chum salmon are listed in Table B1 (Appendix B) and plotted in Figure 2. Peak numbers of threatened chum were observed during a 9-day period in mid-April. There were only 6 mortalities, approximately 0.93 % of the total number of observed threatened chum salmon.

The first and last sampling dates on which chinook salmon were observed were January 24, 2005 and June 13, 2005, respectively. The weekly sampling results of chinook salmon are listed in Table B2 and plotted in Figure 3. Large numbers of chinook salmon were observed throughout the period from mid February through mid June. There were 146 mortalities, approximately 1.1% of the total number of observed chinook salmon.

The first and last sampling dates on which coho salmon were observed were January 31, 2005, and June 13, 2005, respectively. The weekly sampling results of coho salmon are listed in Table B3 and plotted in Figure 4. Peak numbers of coho salmon were observed mid February through mid March, mid April, and the first two weeks of June. There were 26 mortalities, approximately 4.8% of the total number of observed coho salmon.

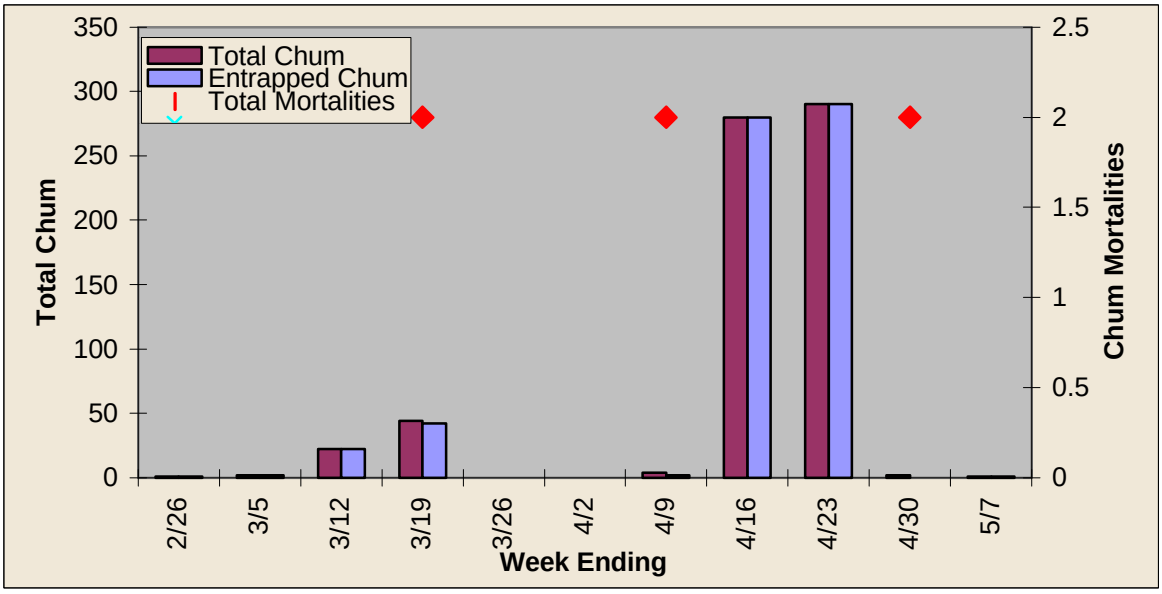

Figure 2. Weekly sampling results of threatened chum salmon. No chum were sampled during the weeks ending 3/26 and 4/2. One chum was sampled in each of the weeks ending 2/26 and 5/7. Two chum were sampled in each of the weeks ending 3/5 and 4/30.

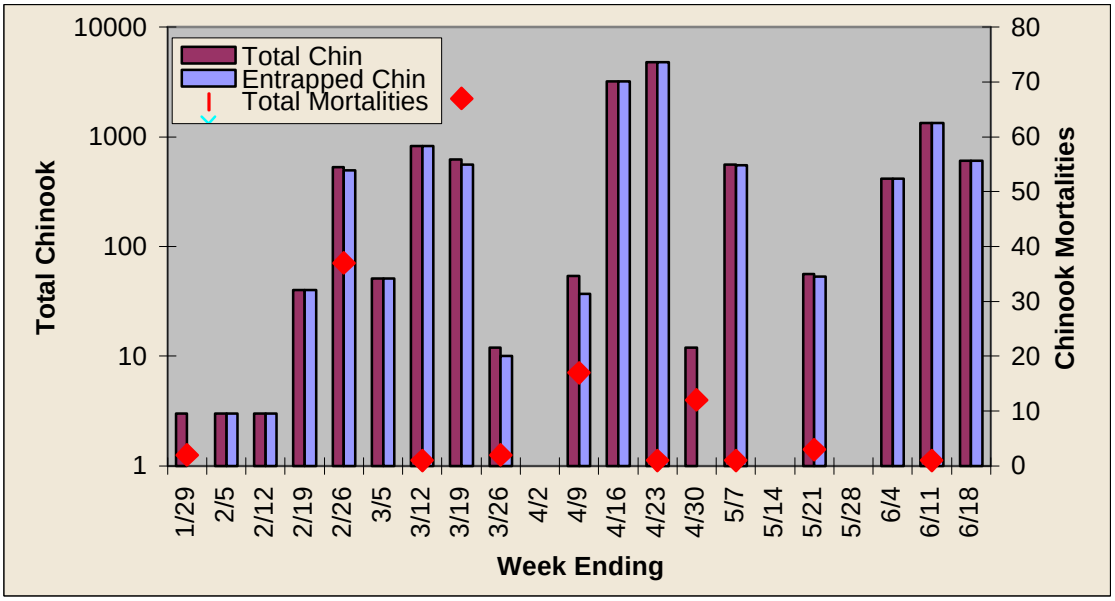

Figure 3. Weekly sampling results of chinook salmon. No Chinook were sampled on each of the weeks ending 4/2, 5/14, and 5/28. Note that the number of Chinook is plotted on a logarithmic scale.

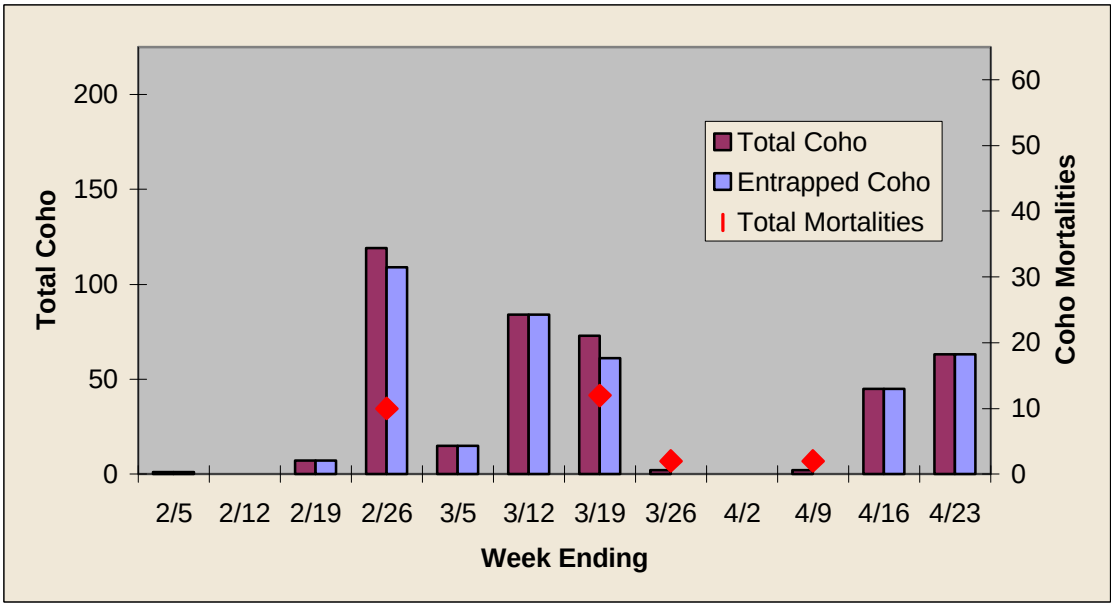

Figure 4. Weekly sampling results of coho salmon. No coho were sampled on each of the weeks ending 2/12, 4/2, 4/30, 5/14, 5/21, 5/28, and 6/4. Between one and three coho were sampled on each of the weeks ending 2/5, 3/26, 4/9, and 5/7.

Distribution

Of all the salmon sampled in 2005, 99.9% were found within four major sampling areas, designated A, C, D, and E (Table 2). Based on cumulative totals, 83.5% of all sampled fish were found within four entrapments (Figure 5, Table 3).

Entrapped chinook salmon comprised the largest numbers in all of the sampling sub units with the exception of Area F, where coho salmon comprised the largest numbers (Table 2).

Approximate river mile boundaries of the six designated sampling areas are given in Table 2. Specific GPS coordinates and approximate river miles for the four entrapments containing the majority of the sampled fish are listed in Table 3. Coordinates for all other entrapment and stranding sites are listed in Appendix A.

Table 2. Spatial distribution of chinook, coho, and threatened chum salmon by sampling area. Numbers in parenthesis represent mortalities.

	Sampling Area						
	A	**B**	**C**	**D**	**E**	**F**	**Other/ Unknown**
River Mile (statute miles)	142.35 to 142.75	142.15 to 142.48	141.9 to 142.25	141.77 to 142	141.8 to 142.2	140.7 To 141.7	
Entrapped Chum	35	0	1	132	472	0	0
Stranded Chum	0	0	0	2 (2)	4 (4)	0	0
Total Chum	35	0	1	134 (2)	476 (4)	0	0
% of all Chum sampled	5.40%	0.00%	0.15%	20.74%	73.68%	0.00%	0.00%
Entrapped Chinook	1359	3 (2)	1633	2357 (2)	7650	0	4
Stranded Chinook	4 (4)	3 (3)	0	104 (104)	31 (29)	1 (1)	1 (1)
Total Chinook	1363 (4)	6 (5)	1633	2461 (106)	7681 (29)	1 (1)	5 (1)
% of all Chin. Sampled	10.37%	0.05%	12.42%	18.71%	58.41%	0.01%	0.04%
Entrapped Coho	129	0	6	247	133	0	0
Stranded Coho	0	1 (1)	0	19 (19)	2 (2)	3 (3)	1 (1)
Total Coho	129	1 (1)	6	266 (19)	135 (2)	3 (3)	1 (1)
% of all Coho Sampled	23.84%	0.18%	1.11%	49.17%	24.95%	0.55%	0.18%
Total Salmon	1527 (4)	7 (6)	1640	2861 (127)	8292 (35)	4 (4)	6 (2)
% of all Salmon Sampled	10.65%	0.05%	11.44%	19.96%	57.84%	0.03%	0.04%

Table 3. Accumulated salmon counts and spatial distribution for entrapment sites containing the majority of sampled fish (includes fish found at stranding sites located within the perimeter of a dewatered entrapment). Numbers in parenthesis represent mortalities.

	Entrapment				
	E501	**E504**	**E507**	**E508**	**E514**
Chum salmon	407	64	3 (2)	131	1
Chinook salmon	6026	1008	182 (107)	2278	1594
Coho salmon	128	5	52 (19)	214	6
Total salmon	6561	1077	237 (128)	2623	1601
% of all sampled salmon	46.33%	7.61%	1.67%	18.52%	11.31%
% of all mortalities	0%	0%	72.7%	0%	0%
River Mile	142.09	142.12	142.05	142	142.11
Latitude	+45.6246990	+45.6246510	+45.6210460	+45.6208980	+45.6207980
Longitude	-122.0059570	-122.0073550	-122.0091310	-122.0096850	-122.0044410
Sampling Area	E	E	D	D	C

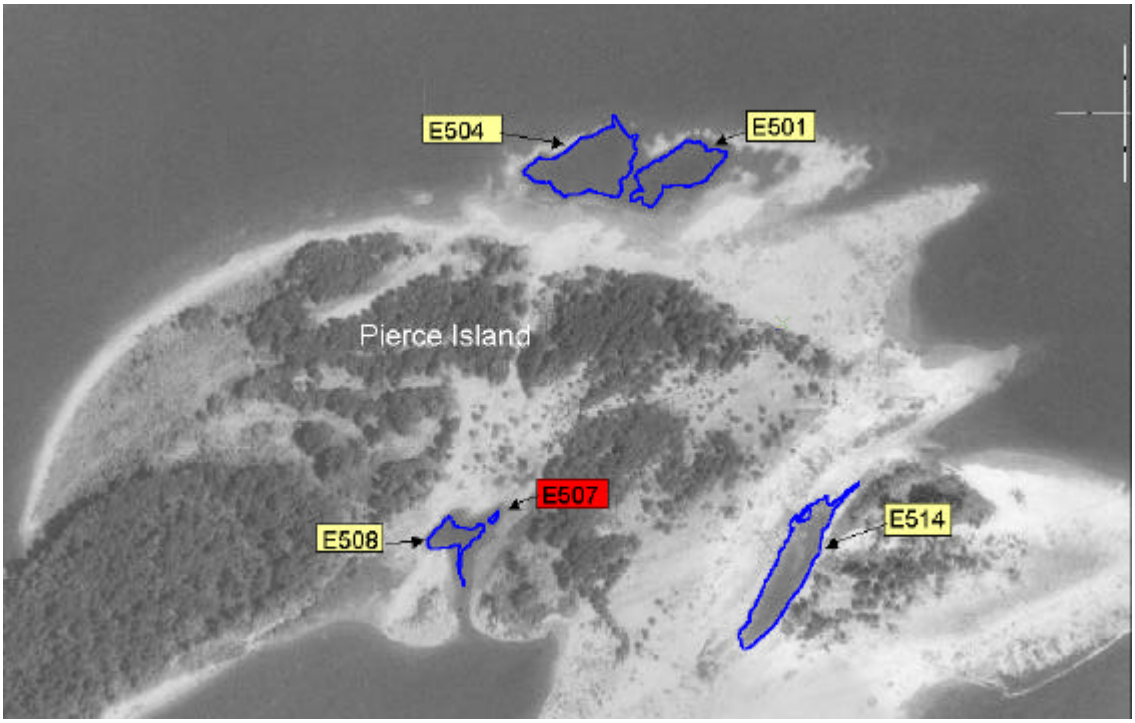

Figure 5: Notable entrapments of 2005, the site in red had high mortality (U.S.G.S. photograph taken 8/3/2000).

Tailwater Levels

614 (99.7%) of the sampled chum were found during March and April when Bonneville tailwater levels ranged between 11.5 and 18.5 feet. The six known chum mortalities were discovered between March 13th and April 30th when Bonneville tailwater levels ranged from 11.5 to 18.5 feet with weekly medians ranging from 11.7 to 15.4 feet (Figures 6 & 7).

419 (77.4%) of the sampled coho were found within two distinct time periods, February 20th through March 19th and June 5th through June 18th when Bonneville tailwater levels ranged between 11.4 and 15.3 feet, and 13.8 and 19.3 feet, respectively. 24 (92.3%) of the known mortalities were discovered between February 20th and March 26th when Bonneville tailwater levels ranged from 11.4 to 15.3 feet with weekly medians ranging from 11.6 to 12.2 feet (Figures 6 & 7).

12412 (94.4%) of the sampled chinook were found in three distinct time frames, February 20th through March 19th, April 10th through April 23rd, and May 29th through June 18th. Bonneville tailwater levels during these time frames ranged between 11.4 and 15.3 feet, 11.6 and 15.6 feet, and 13.8 and 20.3 feet, respectively. 137 (93.8%) of the known chinook mortalities were discovered between February 26th and April 30th when Bonneville tailwater levels ranged from 11.4 to 18.5 feet with weekly medians ranging from 11.6 to 15.4 feet. (Figures 8 & 9).

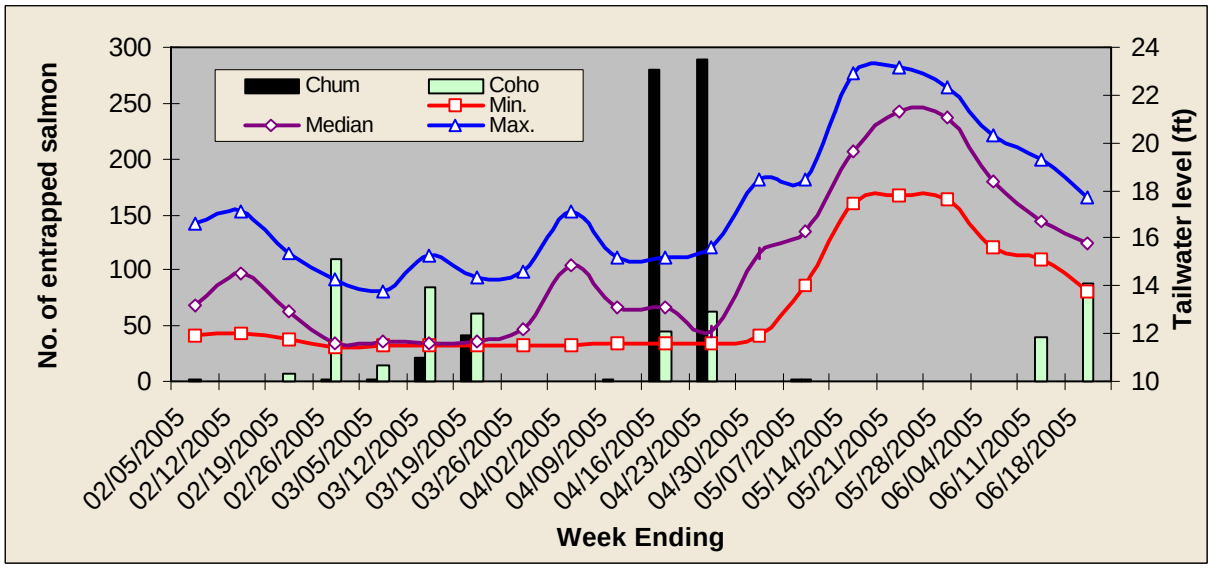

Figure 6: Weekly tailwater measurements associated with entrapped juvenile chum and coho salmon.

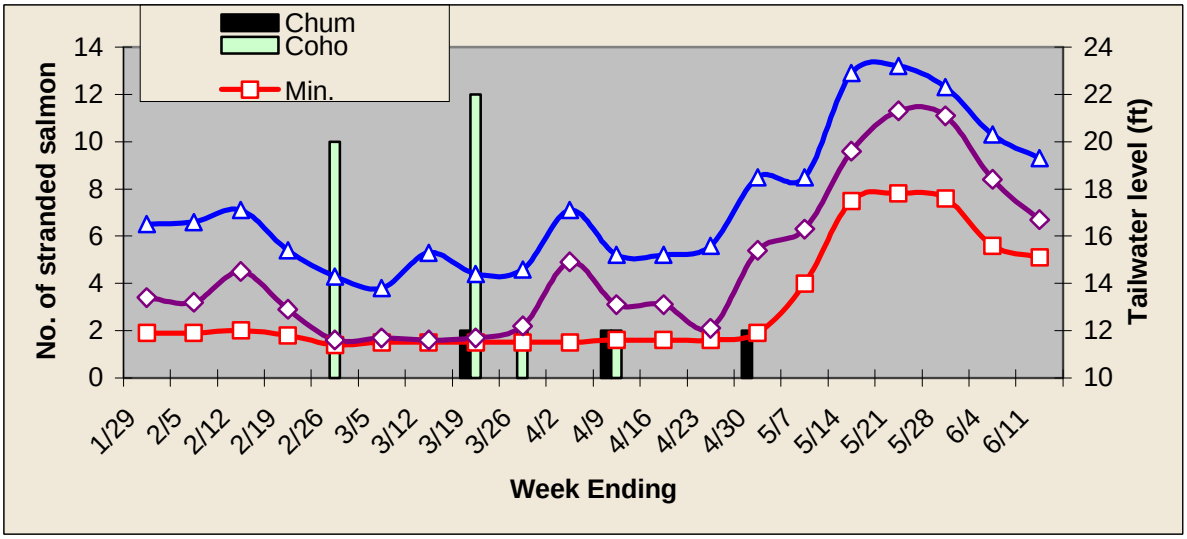

Figure 7: Weekly tailwater measurements associated with stranded juvenile chum and coho salmon.

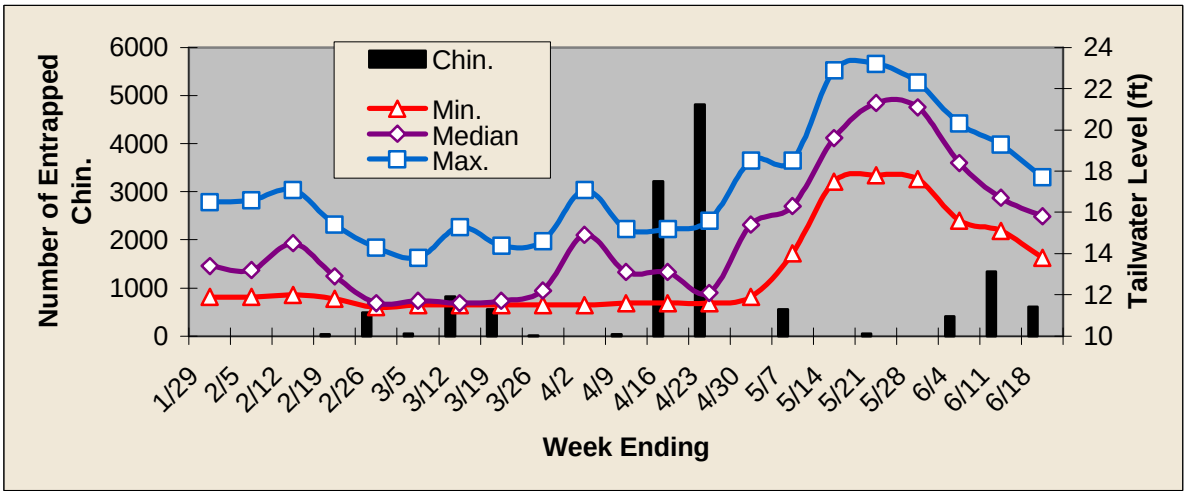

Figure 8: Weekly tailwater measurements associated with entrapped juvenile chinook salmon.

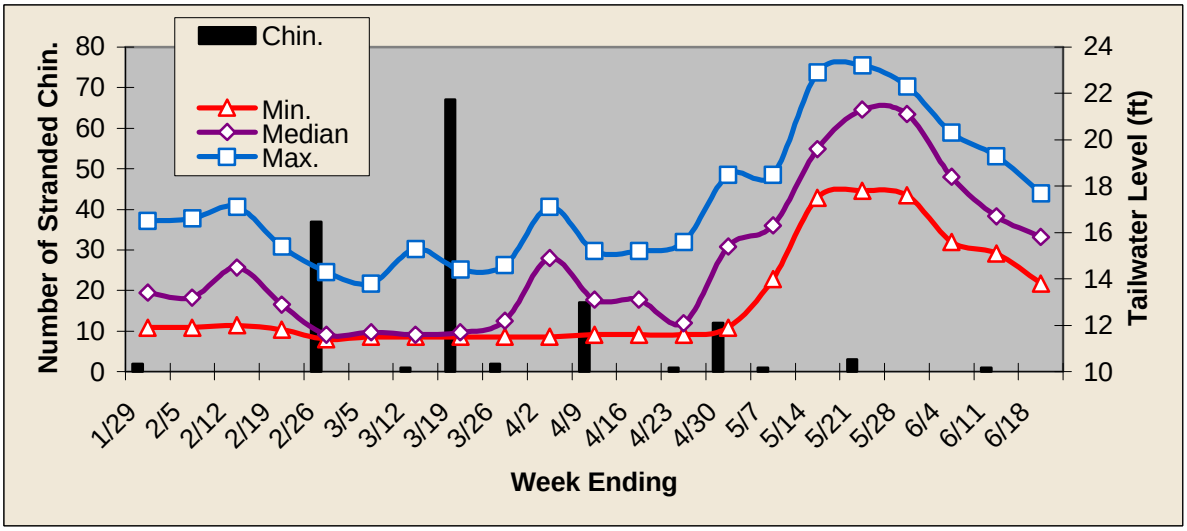

Figure 9: Weekly tailwater measurements associated with stranded juvenile chinook salmon.

The tailwater ranges within which the entrapments containing 83.8% of the salmon were sampled in 2005, as well as the numbers of salmon found in those entrapments, are listed in Table 4.

At least 83.3% of all chum sampled during 2005 were retrieved from entrapments that were likely to have formed when Bonneville Dam tailwater levels dropped to elevations between 11.5 and 12.9 feet. A minimum of 63.1% of all sampled chinook and 63.2% of all sampled coho were retrieved from the same entrapments. An additional 12.1% of sampled chinook were retrieved from entrapments that were likely to have formed when tailwater levels dropped to elevations between 15.9 and 17.5 feet.

Table 4: Tailwater levels associated with the formation of four entrapments containing 83.8% of the juvenile salmon sampled in 2005

ENTRAPMENT CODE SAMPLED SALMON (2005)	SAMPLE DATE	SAMPLE TIME	HEIGHT ABOVE RIVER (ft)	TAILWATER LEVEL AT TIME OF SAMPLING (ft)	TAILWATER 1-2 HR. PRIOR TO SAMPLING (ft)	CRITICAL RANGE (ft)
E508 (Pierce Is.) 131 CHUM, 2278 CHIN, 214 COHO	2/21/05	1100	0.63	11.5	12.0-11.9	**11.5-12.5**
	3/16/05	1100	0	11.9	11.7-11.6	
	3/20/03	1100	0.54	12.0	12.2-12.0	
	1/30/01	1100	0.29	12.2	12.1	
E501 (Pierce Is.) 407 CHUM, 6026 CHIN, 128 COHO	04/10/05	1100	0	12.1	12.1-12.2	**12 to12.9**
	02/29/04	1200	0.27	12.2	12.1-12.1	
	03/08/04	1100	0.03	12	12.0-12.0	
	03/21/04	1300	0.17	12.6	12.9-12.4	
E504 (Pierce Is.) 64 CHUM, 1008 CHIN, 5 COHO	4/12/04	1000	0.02	13.7	13.6-13.5	**12.4-13.8**
	2/17/03	1000	0.90	11.5	11.5	
	4/8/02	900	0.02	13.8	12.8-12.3	
	2/16/01	1100	0.88	13.4	13.4-13.3	
E514 (Pierce Is.) 1 CHUM, 1594 CHIN, 6 COHO	06/06/05	1200	0	17.4	17.2-17	**15.9 to 17.5**
	02/03/04	1000	0.19	15.9	15.9-15.9	
	02/01/02	1100	0.23	16.3	16.2-16.4	
	04/13/03	1100	0.48	16.2	16.1-16.2	

During 2005, 92.3% of all known salmon mortalities, including all stranded salmon, dead or alive, were discovered in either existing or dewatered entrapments. It is believed that dewatering of known entrapments caused over 89.5% of the total salmon mortality.

Two (33%) of the known chum mortalities, 107 (73.2%) of the known chinook mortalities, and 19 (73.1%) of the known coho mortalities were found within a relatively small, shallow entrapment along the south central shore of Pierce Island (E507). Without sampler intervention, an additional sixty-three live salmon that were pulled from this entrapment on February 21st would have been de-watered. These additional sixty-three salmon consisted of one chum, thirty-six chinook, and twenty-six coho. Nearly all of the salmon found at this site became entrapped when tailwater levels dropped and elevations were between 11.9 and 12.9 feet (Table 5).

An additional thirty-one salmon mortalities were found along the northshore of Pierce Island. Twenty-nine of these thirty-one observed mortalities were found stranded, due to de-watering, in two former entrapment sites (E424 & E430). These two sites were not sampled as entrapments in 2005, but have been sampled as entrapments in previous years. Nearly all of the salmon found at these sites became entrapped when tailwater levels dropped and elevations were between 14.1 and 15.2 feet (Table 5).

Table 5: Tailwater levels associated with the formation of entrapments with high mortality (E424 & E430 were not sampled as entrapments in 2005, but strandings were found at these sites).

ENTRAPMENT CODE SALMON MORTS (2005)	SAMPLE DATE	SAMPLE TIME	HEIGHT ABOVE RIVER (ft)	TAILWATER LEVEL AT TIME OF SAMPLING (ft)	TAILWATER 1-2 HR. PRIOR TO SAMPLING (ft)	CRITICAL RANGE (ft)
E507 (Pierce Is.) 2 CHUM, 107 CHIN, 19 COHO	2/14/05	1100	0.04	12.4	12.5	**11.9-12.9**
E424 (Pierce Is.) 1 CHUM, 10 CHIN	05/01/05	1400	0	14.6	14.5-14.4	**14.1-15.1**
	04/26/04	1300	0.375	14.6	14.6-14.6	
E430 (Pierce Is.) 2 CHUM, 14 CHIN, 2 COHO	05/02/04	1000	0	14.7	14.7-14.8	**14.2-15.2**

The mean degree of fluctuation (the difference between the highest and lowest level) and the mean degree of continuous decline in Bonneville tailwater during the 24-hour periods preceding the discovery of juvenile salmon mortality were nearly identical.

The degree of fluctuation in Bonneville tailwater during the 24-hour periods preceding the discovery of chum salmon mortalities ranged from 0 to 1.5 feet and 2.51 to 3.0 feet (Figure 10). The degree of continuous tailwater decline during the same periods ranged from 0 to 0.5 feet, 1.01-1.5 feet, and 2.01 to 2.5 feet (Table B4, Figure 12)

The degree of fluctuation in Bonneville tailwater levels during the 24-hour periods preceding the discovery of chinook salmon mortalities ranged from 0 to 0.5 feet, 1.01 to 1.5 feet, and 2.01 to 3.0 feet. 70.5% of chinook mortalities were preceded by fluctuations of 0 to 0.5 feet (Figure 11). The degree of continuous tailwater decline during the same periods ranged from 0 to 1.5 feet and 2.51 to 3.0 feet (Table B4, Figure 12)

The degree of fluctuation in Bonneville tailwater levels during the 24-hour periods preceding the discovery of coho salmon mortalities ranged from 0 to 1.0 feet and 2.01 to 3.0 feet (Figure 11). The degree of continuous tailwater decline during the same periods ranged from 0 to 1.0 feet and 2.0 to 2.5 feet (Table B4, Figure 12)

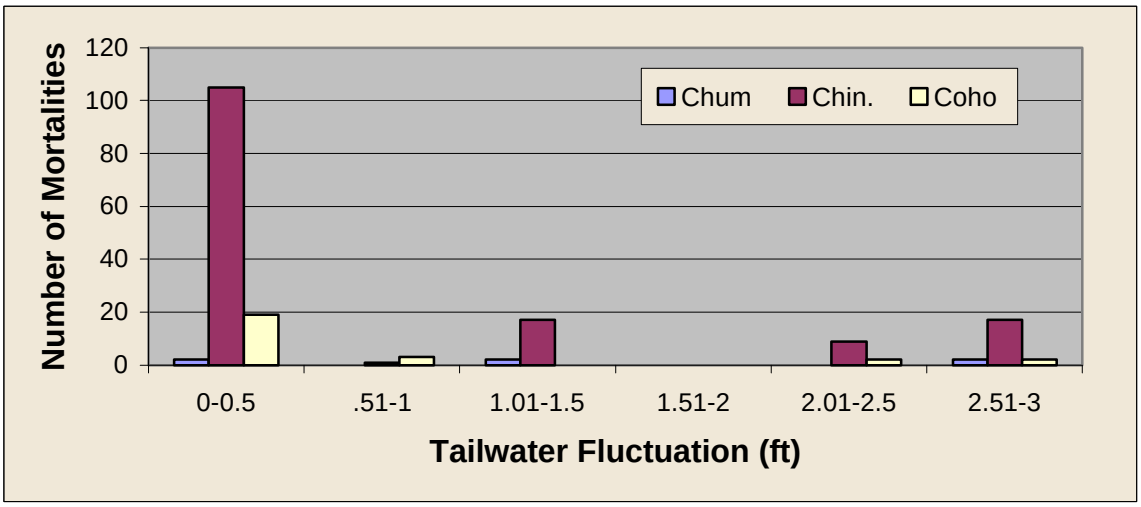

Figure 10: Maximum tailwater fluctuation during the 24 hr. periods immediately preceding known salmon mortality

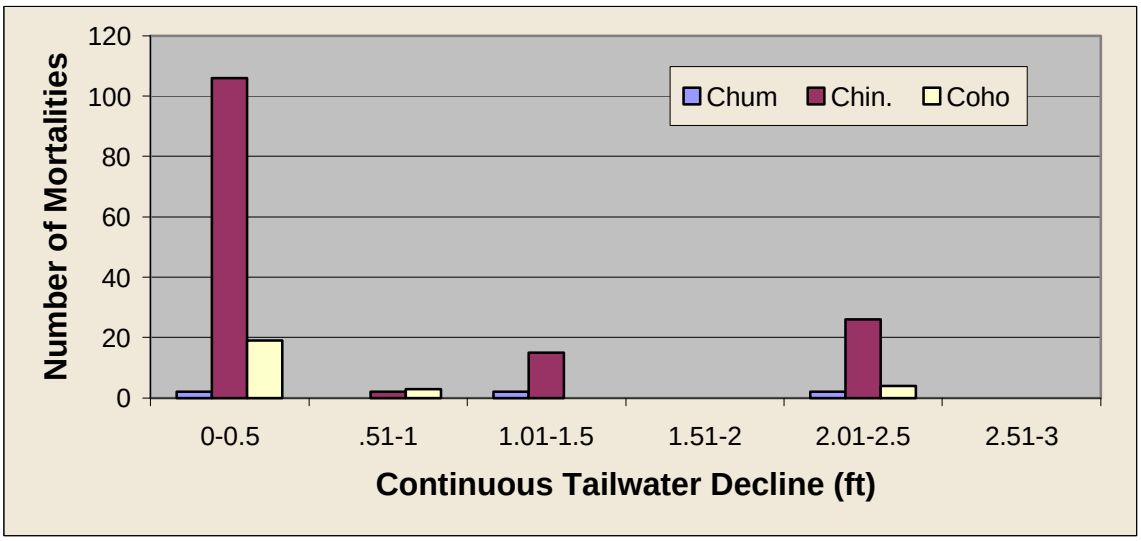

Figure 11: Degree of maximum continuous tailwater decline during the 24 hr. periods immediately preceding known salmon mortality

The actual levels of continuous tailwater declines during the twenty-four hour periods immediately preceding the sampling of salmon mortality, including all stranded salmon whether found living or dead, are also identified in Table B4. All of the known chum and coho mortalities and over ninety-six percent of chinook were preceded by continuous tailwater declines that began at levels no higher than 15.4 feet and ended at levels no lower than 11.5 feet. When taken as a whole, 97.2% of all known salmon mortalities were preceded by continuous tailwater declines beginning at levels no higher than 15.4 feet and ending at levels no lower than 11.5 feet (Table B4).

Size Susceptibility

Mean, maximum, and minimum fork lengths for entrapped chum, chinook, and coho salmon are found in Tables B5, B6, and B7 respectively.

Minimum and maximum fork lengths of entrapped chum salmon were plotted as the two ends of the vertical bars for each sampling date in Figure 12, along with the median fork length (horizontal bars). The weekly median fork length for entrapped chum salmon ranged from 40 to 43 mm prior to April 9th and from 47 to 56 mm after April 9th. The mean fork length for chum entrapped prior to April 9th was 42 mm and 48.5 mm after April 9th.

Minimum and maximum fork length of entrapped chinook salmon were plotted as the two ends of the vertical bars for each sampling date in Figure 13, along with the median fork length. The median fork length for entrapped chinook salmon ranged from 37-46 mm prior to May 7th and 51-76.5 mm after May 7th. The mean fork length for entrapped chinook was 44 mm prior to May, 46.4 mm during May, and 54.4 mm in June.

Minimum and maximum fork length of entrapped coho salmon were plotted as the two ends of the vertical bars for each sampling date in Figure 14, along with the median fork length. The weekly median ranged from 36-46 mm prior to June. During the month of June, 128 coho salmon were sampled with weekly medians ranging from 75-76.5 mm. The mean fork length for entrapped coho was 44.2 mm prior to June and 77.1 mm during June.

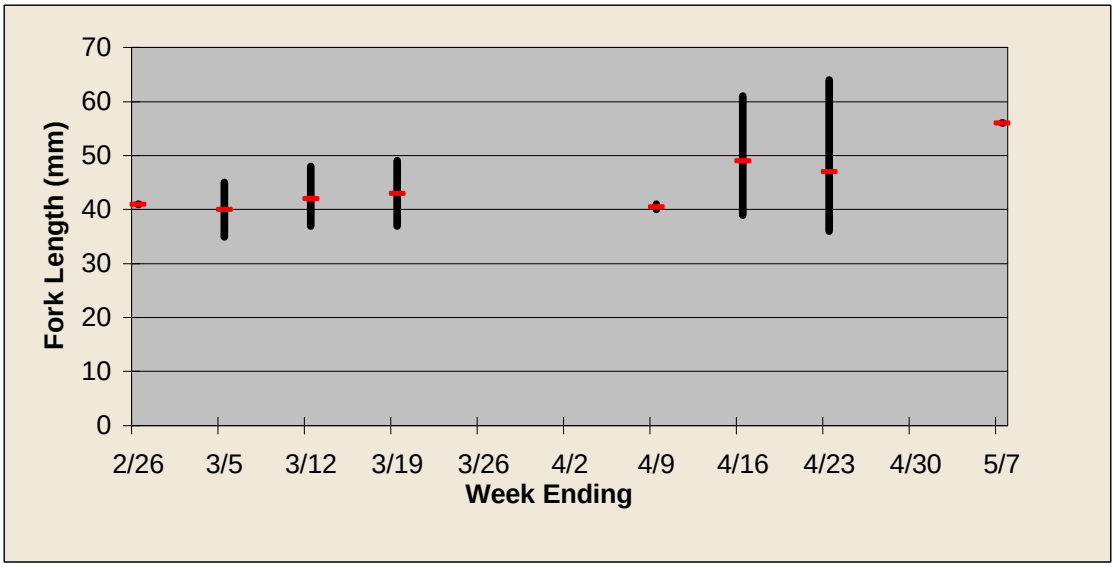

Figure 12. Minimum, maximum and median fork length of threatened chum salmon collected at entrapment sites near the Ives Island of the Columbia River in 2005. The lower and higher ends of the vertical lines represent the minimum and maximum fork length observed in the sample for the week, with the horizontal bars as the median fork lengths.

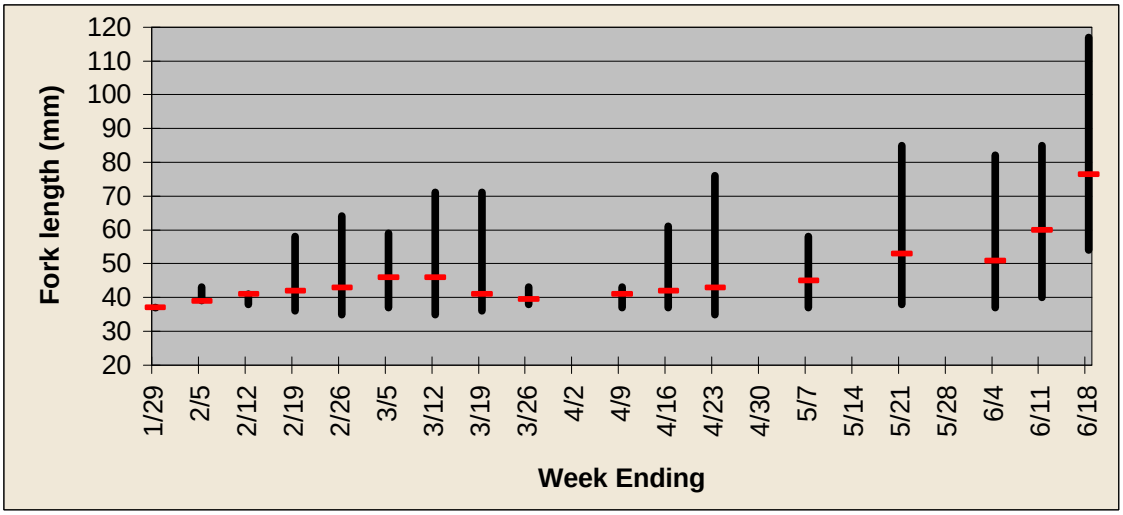

Figure 13. Minimum, maximum and median fork length of chinook salmon collected at entrapment sites near Ives Island of the Columbia River in 2005. The lower and higher ends of the lines represent the minimum and maximum fork length observed in the sample for the week, with the horizontal dashes as the median fork lengths.

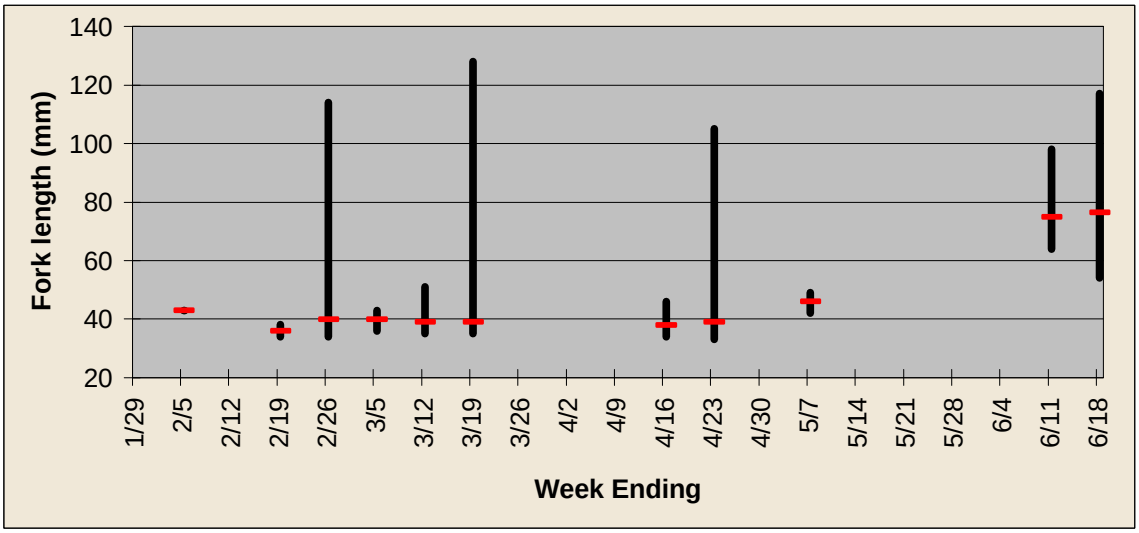

Figure 14. Minimum, maximum and median fork length of coho salmon collected at entrapment sites near the Ives Island of the Columbia River in 2005. The lower and higher ends of the lines represent the minimum and maximum fork length observed in the sample for the week, with the horizontal dashes as the median fork length.

Fork length summaries for stranded chum, chinook, and coho salmon are listed in Tables B8, B9, B10, respectively. The mean fork length of stranded chum was 43.8mm, 8.2% shorter than the mean fork length of sampled entrapped chum salmon (47.7mm). The mean fork length of stranded coho salmon was 37mm, 30.3% shorter than the mean fork length of sampled entrapped coho (52.3mm). The mean fork length of stranded chinook salmon was 41.6mm, 12.8% shorter than the mean fork length of sampled entrapped chinook (47.7mm).

We tested the statistical significance of the difference between the fork length of entrapped and stranded salmon for weeks where both entrapped and stranded salmon were sampled for each species. For chum salmon, the samples that were compared were for the weeks of 3/19 and 4/9; for coho salmon the weeks were 2/26 and 3/19; and for chinook, the weeks for which comparisons were made were 2/26, 3/12, 3/19, 3/26, and 4/9. During the weeks that both entrapped and stranded salmon of each species were sampled, the mean fork lengths for stranded chum, chinook, and coho were 44.3 mm, 41.0 mm, and 37.0 mm, respectively, whereas the mean fork lengths for entrapped chum, chinook, and coho during the same weeks were 43.0 mm, 46.7 mm, and 49.3 mm, respectively. The differences in mean fork length between entrapped and stranded salmon were significant at the 95% confidence level for chinook and coho ($p < 0.0005$), but not for chum. Thus, it appears that the fork lengths of entrapped chinook and coho salmon are significantly larger than those of stranded chinook and coho, with mean fork length differences of 5.7 mm for chinook and 12.4 mm for coho.

Substrate Size

The most common substrate in a sampled area is defined as the dominant substrate, and the next most common substrate as the subdominant substrate. Substrate size was estimated visually using the same coding employed by Nugent et al. (2002). A key for the different substrate sizes can be found immediately before Table B11.

Entrapped chum salmon were observed at sites with dominant substrate sizes of fines, coarse gravel, small pebble, large pebble, and cobble. Coarse gravel appeared most often (42.1% of the time) and accounted for 63.8% of all entrapped chum salmon. Sites with a dominant substrate made up of fines contained 30.6% of the entrapped chum (Table B11).

Stranded chum salmon (those found dewatered) were observed at sites with dominant substrates of fines, coarse gravel, and small pebble. Coarse gravel appeared most often (50% of the time) and accounted for 50% of all sampled stranded chum (Table B12).

Entrapped chinook salmon were observed for dominant substrates the size of fines, coarse gravel, small pebble, large pebble, and cobble. The dominant substrates fines and coarse gravel appear most often, cumulatively accounting for 70.8% of the chinook salmon entrapment sites. The largest numbers of entrapped chinook, 33.2% and 58.8%, were also observed at sites with dominant substrates of fines and coarse gravel, respectively (Table B13).

Chinook mortalities found in entrapments were observed at sites containing dominant substrates of fines, small pebble, and large pebble. Each appeared in relatively similar frequency and had similar numbers of mortalities.

Stranded chinook salmon (those found dewatered) were observed at sites with dominant substrates of fines, coarse gravel, small pebble, large pebble, and cobble. Fines appeared most often (33% of the time) and accounted for 75.7% of all stranded chinook sampled (Table B14).

Entrapped coho salmon were observed for dominant substrate sizes of fines, coarse gravel, large pebble, and cobble. The substrate fines appeared with the most often (62.3% of the time). Sites

with a dominant substrate of fines and coarse gravel accounted for 83.4% of the entrapped coho sampled (Table B15).

Stranded coho salmon (those found on dry land) were observed at sites with dominant substrates of fines, small pebble, and large pebble. Most sampled stranded coho (88.5%) were observed at sites with a dominant substrate of fines (Table B16).

Substrate Embeddedness

The substrate embeddedness refers to the degree that the interstices between the larger particles are filled by sand, silt or clay. The substrate embeddedness was estimated visually using the same coding employed by Nugent et al. (2002). A key that provides the embeddedness classes is provided immediately before Table B17.

The majority of entrapped chum salmon (69.2%) were found at sites with substrate embeddedness of 25 to 50% fines. The mean and median numbers of threatened chum salmon per survey site found in entrapment sites with various degrees of substrate embeddedness are listed in the last two rows of Table B17.

Stranded chum occurred in equal frequency between sites with substrate embeddedness of 25 to 50%, 50 to 75%, 75 to 100%. The mean and median numbers of threatened chum salmon per survey site found at stranding sites with various degrees of substrate embeddedness are listed in the last two rows of Table B18.

Entrapped chinook occurred most often at sites with substrate embeddedness of 25 to 50%. The 5 chinook entrapment mortalities were found in sites with substrate embeddedness of 0 to 25%, 25 to 50%, and 75 to 100%. The mean and median number of chinook salmon per survey site found in entrapment sites with various degrees of substrate embeddedness are listed in the last two rows of Table B19.

The majority of stranded chinook (75.7%) occurred in sites with substrate embeddedness of 75 to 100%. 97.9% of all stranded chinook were mortalities. The mean and median number of chinook salmon per survey site found at stranding sites with various degrees of substrate embeddedness are listed in the last two rows of Table B20.

Sites with substrate embeddedness of 25 to 50% occurred most often and accounted for 27% of all entrapped coho sampled. The majority of entrapped coho (61.4%) were observed at sites with a substrate embeddedness of 75 to 100%. The mean and median numbers of coho salmon per survey site found in entrapment sites with various degrees of substrate embeddedness are listed in the last two rows of Table B21.

The majority of stranded coho sampled (88.5%) occurred at sites with substrate embeddedness of 75 to 100%. All stranded coho were mortalities. The mean and median numbers of coho salmon

per survey site found in stranding sites with various degrees of substrate embeddedness are listed in the last two rows of Table B22.

Vegetation Density

Vegetation density refers to the amount of substrate concealed by vegetation. Vegetation density was estimated visually using the same coding employed by Nugent et al. (2002). A key that provides the embeddedness classes is located immediately before Table B23.

During the 2005 field season, entrapments with medium and dense vegetation contained primarily aquatic plants, including algae. Chinook and coho salmon were found in areas of all four vegetation densities, while chum salmon were found in areas with no vegetation, sparse vegetation, or medium vegetation. The majority of chum entrapment sites contained sparse vegetation and the greatest numbers of entrapped chum salmon (605) were found in these sites (Table B23).

The greatest numbers of stranded chum salmon (83.3%) were found in sites with sparse vegetation (Table B24).

The majority of chinook entrapment sites contained sparse vegetation and the greatest numbers of entrapped chinook salmon (11,033) were found at these sites (Table B25).

All five chinook mortalities were discovered in entrapments containing sparse vegetation (Table B25).

The greatest numbers of stranded chinook (89.6%) were also found at sites with sparse vegetation (Table B26).

The majority of coho entrapment sties contained sparse vegetation and the greatest numbers of entrapped coho (316) were found at these sites (Table B27).

The greatest numbers of stranded coho (84.6%) were found at sites with sparse vegetation (Table B28).

Temperature

The temperatures of entrapments known to contain any juvenile salmon ranged from 44ºF to 74ºF (Table 6). The temperature of the entrapments known to contain any salmon mortalities ranged from 42ºF to 69ºF.

Table 6. Temperature ranges of entrapments with and without salmon mortality

Month	Temp range of entrapments with salmon mortality	Temp range of entrapments with salmon but without mortality
Jan	NA	NA
Feb	45F-54F	44F-60F
March	42F	44F-74F
April	NA	50F-62F
May	NA	54F-70F
June	69F	60F
July	NA	NA

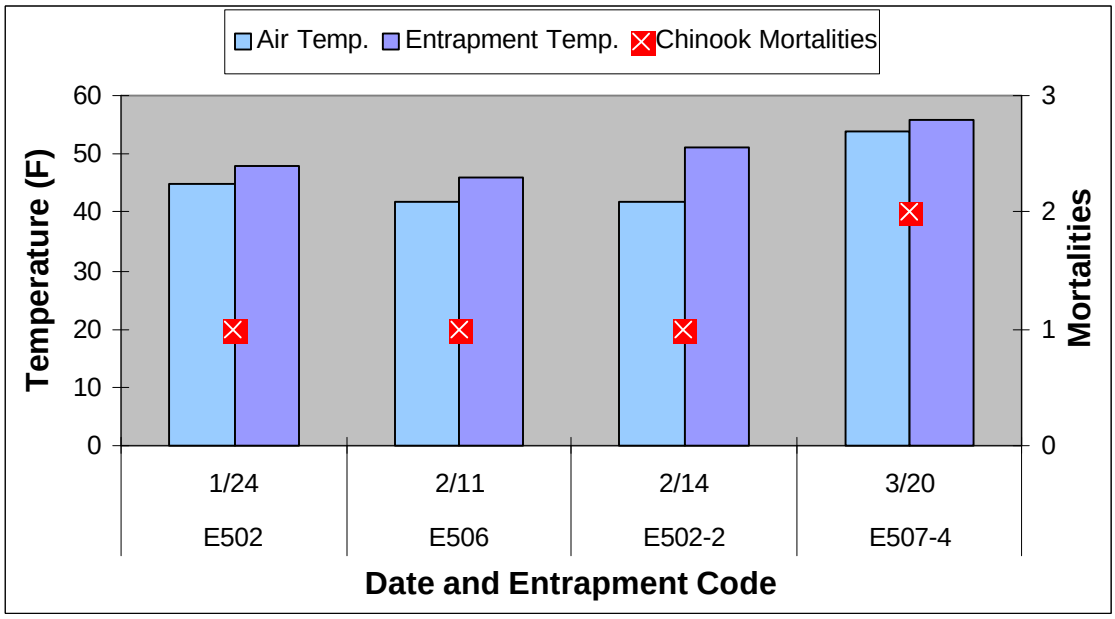

Figure 15. Mortality of chinook salmon and temperatures measurements at entrapment sites near Ives Island of the Columbia River in 2005.

DISCUSSION

Major Entrapments of 2005

In 2005, there were four major entrapments containing 83.8% of the total salmonids sampled and one other entrapment that was responsible for 72.3% of the total mortalities found. The following are brief descriptions of these noteworthy entrapments.

E501 (46.33% of all sampled salmon) is a broad shallow pond forming just east of E504 along the north central shore of Pierce Island. When at its largest stage, E501 had a surface area of approximately .9 acre. Water backs into it via a larger and deeper pond to the west, E504, and, when high enough, flows into it from the channel separating Ives and Pierce Islands to the east.

E501 is within a large area of undulating topography, which includes many other lesser entrapments.

E504 (7.61% of all sampled salmon) is a relatively deep entrapment that forms on the north central shore of Pierce Island just west of E501. At its maximum entrapment size, it has a surface area of approximately .97 acres.

E507 (1.67% of all sampled salmon and 72.3% of all sampled mortalities) is a shallow, sandy-bottomed entrapment that forms just east of E508. At its maximum, it has a surface area of approximately 475 square feet (0.01 acres). River water reaches this entrapment via E508.

E508 (18.52% of all sampled salmon) is a bay along the south central shore of Pierce Island with a narrow entrance leading to the main channel of the Columbia River. The entry to E320 is lower than any of the other major entrapments and formation of E508 appears to require tailwater levels somewhere below 12 feet.

E514 (11.31% of all sampled salmon) was the largest of all the entrapments. E401 occupies a portion of a broad floodplain that cuts through the eastern portion of Pierce Island. When tailwater levels are in excess of 17 feet, water flows from the channel between Ives and Pierce Islands southward through E401 to the main channel of the Columbia River.

Temperature

In most cases, the two entrapment temperatures taken were identical because of a short time interval between measurements and/or the lack of direct sunlight. On warm sunny days, samplers returned late in the afternoon to take additional temperature measurements of entrapments from which juvenile salmon had already been removed.

It is unlikely that any salmon found entrapped were exposed to water temperatures warm enough to be considered lethal to salmon. Water temperatures of 78ºF and above are considered lethal to juvenile chum and coho salmon (Bell 1973). Water temperatures of 77ºF and above are considered lethal to juvenile chinook salmon (Brett 1952). The highest water temperature found for any entrapment containing juvenile salmon was 69ºF. Of the 14,161 sampled juvenile salmon found in entrapments, only 5 (0.035%) were found dead, and of those, none were found in water exceeding 78ºF.

Even though the majority of salmon found in this study were entrapped fish that were released back to the Columbia River alive, these fish still have the possibility of delayed mortality. Delayed mortality results from two primary sources, predation and altered fish behavior due to sub-lethal heat stress (Mesa and Weiland 1998). The extent of delayed mortality in the Ives Island area has not been quantified.

Year-to-Year Comparison

Table 7 provides a comparison of the number of fish sampled during each of the six study years. The majority of the fish that have been sampled during that time were associated with six major entrapments shown in Figure 16, with sampling results for each of those entrapments provided in Table 8. This section provides a discussion of each of these entrapments, as well as an additional three entrapments that have produced substantial mortalities. The location of the entrapments with high mortality are also shown in Figure 16. The section will also address possible reasons for the significant increase in the number of entrapped chinook and the decrease in the number of mortalities found in 2005.

Table 7. Sampling totals by study year (stranded salmon observed alive are listed as live).

Study Year	Live Chinook	Live Chum	Live Coho	Dead Chinook	Dead Chum	Dead Coho	Total
2000 (Mar. 2 - June 27)	1258	3	0	53	5	0	1319
2001 (Jan. 29 - June 26)	783	404	349	47	37	1	1621
2002 (Jan. 25 - July 10)	1061	597	415	53	61	85	2272
2003 (Jan. 24 - June 25)	4135	422	1440	61	7	57	6122
2004 (Jan. 22 - June 20)	6208	502	456	434	131	93	7824
2005 (Jan. 10 – June 15)	13004	640	515	146	6	26	14337

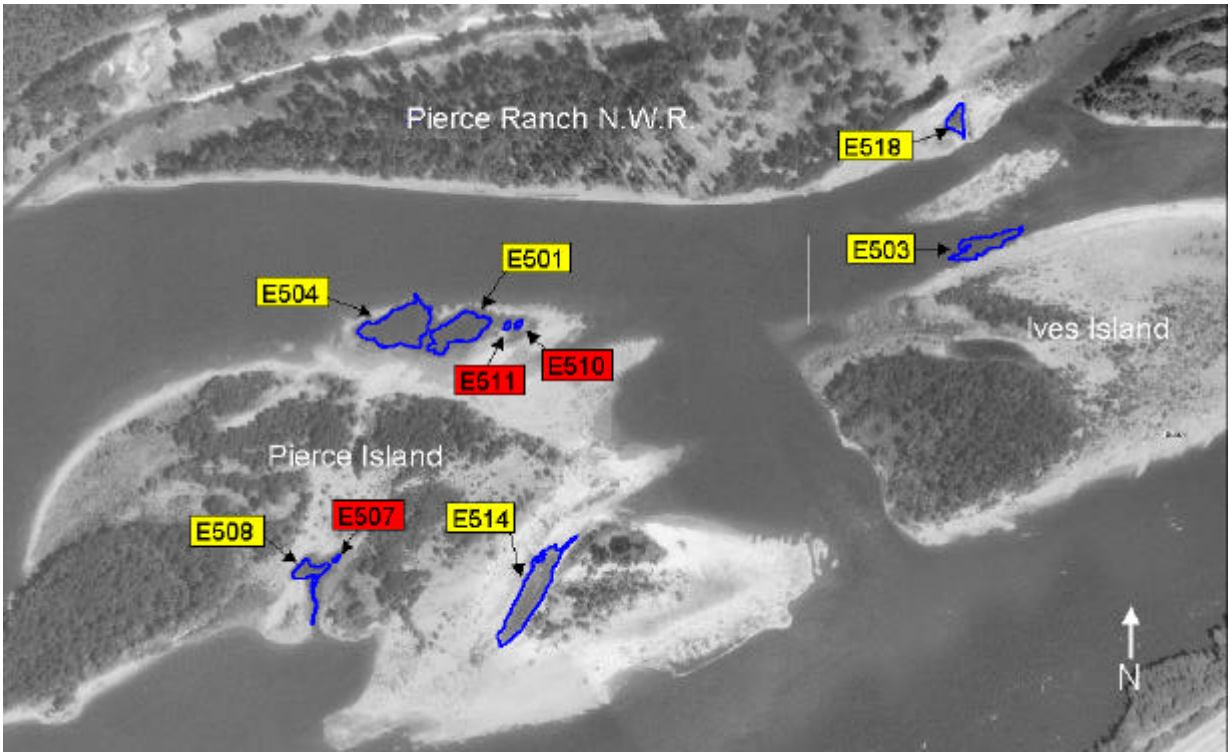

Figure 16: Major entrapments of 2000 - 2005. (U.S.G.S. photograph taken 8/3/2000) (Sites in yellow are the six major entrapments. Sites in red are entrapments that have produced large numbers of mortalities).

Table 8. Yearly sampling totals per major entrapment

Entrapment And Year	Total Chinook (% of yearly chin)	Total Chum (% of yearly chum)	Total Coho (% of yearly coho)	Dead Chin	Dead Chum	Dead Coho
E501, formally E414 ('04), E317 ('03), E210 ('02), PIN112 ('01) - (Pierce Island)						
2000	Flooded all season?	NA	NA	NA	NA	NA
2001	250 (30.1%)	136 (30.9%)	89 (25.4%)	0	0	0
2002	291 (26.1%)	401 (60.9%)	176 (35.2%)	0	0	1
2003	41 (1.0%)	0	9 (0.6%)	4	0	0
2004	408 (6.1%)	133 (21.0%)	94 (17.1%)	0	0	0
2005	6026 (45.8%)	407 (63.0%)	128 (23.7%)	0	0	0
E503, formally E406 ('04), E301 ('03), E234 ('02), IIN113 ('01) - (Ives Island)						
2000	Flooded all season.	NA	NA	NA	NA	NA
2001	41 (4.9%)	72 (16.4%)	36 (10.3%)	0	0	0
2002	38 (3.4%)	92 (14%)	43 (8.6%)	0	0	0
2003	190 (4.5%)	113 (26.3%)	78 (5.2%)	8	1	1
2004	1195 (18.0%)	158 (25.0%)	170 (31.0%)	0	0	0
2005	608 (4.6%)	34 (5.3%)	5 (0.9%)	0	0	0
E508, formally E320 (03'), PIM103 ('01) - (Pierce Island)						
2000	Flooded all season?	NA	NA	NA	NA	NA
2001	225 (27%)	166 (37.6%)	203 (58%)	0	0	1
2002	Flooded all season.	NA	NA	NA	NA	NA
2003	373 (8.9%)	8 (1.9%)	131 (8.8%)	0	0	0
2004	Flooded all season.	NA	NA	NA	NA	NA
2005	2278 (17.3%)	131 (20.3%)	214 (39.6%)	0	0	0
E514, formally E401 ('04), E316 ('03), E208 ('02), PIE31 ('00) - (Pierce Island)						
2000	86	0	0	0	0	0
2001	Dry all season.	NA	NA	NA	NA	NA
2002	0	0	0	0	0	0
2003	1933 (31.6%)	160 (37.3%)	694 (46.4%)	0	0	0
2004	2727 (41.0%)	2 (0.3%)	23 (4.2%)	0	0	0
2005	1594 (12.1%)	1 (0.2%)	6 (1.1%)	0	0	0
E516, formally E432 ('04), E315 ('03), E274 ('02), PIN46 ('00) - (Pierce Island)						
2000	721 (55%)	0	0	6	0	0
2001	Dry all season.	NA	NA	NA	NA	NA
2002	229 (20.6%)	52 (7.9%)	0	0	0	0
2003	541 (12.9%)	1 (0.2%)	34 (2.3%)	24	0	28
2004	88 (16.0%)	0	0	0	0	0
2005	582 (4.4%)	0	0	1	0	0
E518, formally E431 ('04), E308 ('03), E279 ('02) - (Pierce Ranch N. W.R.)						
2000	Too deep to sample.	NA	NA	NA	NA	NA
2001	Never connected to river.	NA	NA	NA	NA	NA
*2002	241 (21.6%)	6 (0.9%)	65 (13%)	0	0	0
2003	945 (22.5%)	110 (25.6%)	446 (29.8%)	0	0	0
2004	457 (6.9%)	2 (0.3%)	8 (1.5%)	0	0	0
2005	386 (2.9%)	0	55 (10.2%)	0	0	0

***In 2002,the sampling crew switched from a 30ft stick seine net to a 100ft beach seine net when sampling E518.

E501 contained 25.6% of all sampled salmon and 38.3% of all sampled chum during the 2000, 2001, 2002, 2003, 2004, and 2005 sampling periods.

E501 had a maximum surface area of approximately 0.91 acre and was a broad shallow pond forming N.E. of E516 along the north central shore of Pierce Island. Water backs into it via a larger and deeper pond to the west (E504) and, when high enough, flows into it from the channel separating Ives and Pierce Islands to the east. Although only small numbers of dead salmon have been documented within this entrapment, the possibility of high water temperatures due to E501's shallowness poses a serious threat to entrapped salmon on sunny days. E501 is part of a large area of undulating topography, which includes many other smaller entrapments including E510 and E511, the two entrapments with the greatest number of salmon mortality in 2004.

E501 has trapped more threatened chum than any other entrapment during the 6 years of sampling.

E503 contained 8.6% of all sampled juvenile salmon and 16.7% of all sampled chum during the 2000, 2001, 2002, 2003, 2004, and 2005 sampling periods.

E503 had a maximum surface area of approximately 0.6 acre and was a long shallow depression in what was a dry channel along the northwest shore of Ives Island across from and just west of Hamilton Creek. Water flowing into the area comes from Hamilton Channel. The surface waters of Hamilton Channel were, at times, higher than E503 but blocked by a broad low-lying berm. In some cases, subsurface flow, probably coming from Hamilton Channel, replenished water within E503 without allowing entrapped salmon an opportunity to escape.
E508 contained 11.1% of all sampled salmon and 10.8% of all sampled chum during the 2000, 2001, 2002, 2003, 2004, and 2005 sampling periods.

E508 had a maximum surface area of approximately 0.34 acre and was a cut off silt bottomed bay on the south central shore of Pierce Island with a narrow entrance leading to the main channel of the Columbia River. The formation of E508 appears to require tailwater levels somewhere below 12 feet. The entry to E508 is lower than any of the other major entrapments with the exception E507, which forms via E508.

E514 contained 21.6% of all sampled salmon and 5.8% of all sampled chum during the 2000, 2001, 2002, 2003, 2004, and 2005 sampling periods.

E514 had a maximum surface area of approximately 1.55 acres, the largest maximum surface area of any of the entrapments, its' length and maximum width dimensions can be in excess of 675 feet and 102 feet, respectively. E514 occupies a portion of a broad floodplain that cuts through the eastern portion of Pierce Island. When tailwater levels are in excess of 17 feet, water flows from the channel between Ives and Pierce Islands southward through E514 to the main channel of the Columbia River.

E516 contained 6.7% of all sampled juvenile salmon and 1.9% of all sampled chum during the 2000, 2001, 2002, 2003, 2004, and 2005 sampling periods.

E516 had a maximum surface area of approximately 0.44 acre and was in a deep, straight channel cut through large cottonwoods in north central Pierce Island. Water flows into the entrapment from the north and, when high enough, exits to the south flowing through E307 and eventually into the lagoon (E508) in Pierce Island's south central shore. E516 has the appearance of a man made channel, possibly to provide increased flow for the Ladzick fishwheel near the center of Pierce Island (Donaldson). A berm of natural deposits has formed at its' north entrance. Cutting off water flow through E516 would reduce the likelihood of E307 becoming an entrapment.

E518 contained 8.1% of all sampled juvenile salmon and 4.2% of all sampled chum during the 2000, 2001, 2002, 2003, 2004, and 2005 sampling periods.

E518 had a maximum surface area of approximately 0.24 acre and was in a deep depression on the Pierce Ranch N. W. R. immediately below the mouth of Hamilton Creek. It may be an old quarry pit resulting from the construction of the nearby Castle Rock Fishwheel and the Hamilton fishwheel scow (Donaldson).

When compared to the previous five study years, there was a substantial increase in the total number of chinook found entrapped or stranded in 2005. There are several factors that may contribute to this increase, such as an increase in the spawning population of chinook near Ives Island, Bonneville Dam tailwater levels during peak chinook emergence, sampler efficiency, and simply the chance that salmonids were utilizing specific rearing habitats that made them susceptible to tailwater declines.

Compared to 2003, there was a 13.4% increase in the spawning population of chinook near Ives Island in 2004 (Fish Passage Center 2005). Although no annual production estimates were made, one can assume this increase should have caused higher juvenile chinook production in the spring of 2005. Figure 17 plots the yearly stranding and entrapment totals with the juvenile index seining conducted by PSMFC and Oregon Department of Fish and Wildlife (ODFW). Index seining was conducted on a bi-weekly basis from mid-January through June. Figure 17 suggests that production has increased substantially since 2002. The low numbers in 2002 were probably caused by the extreme low water levels during the 2001 drought year.

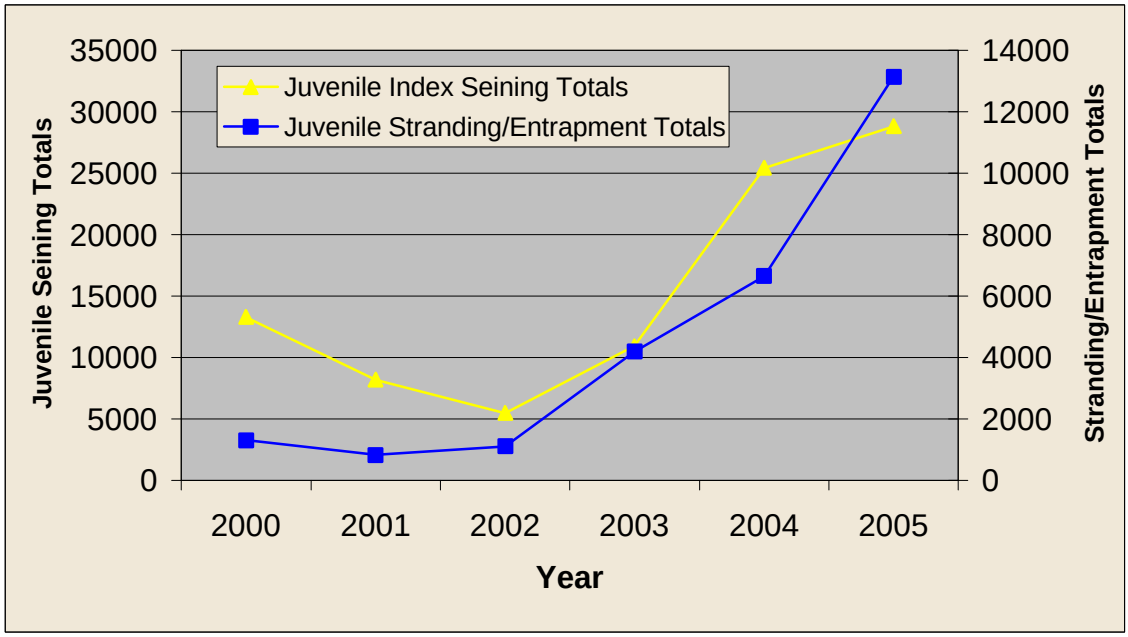

Figure 17: Yearly Juvenile Index Seining and Stranding/Entrapment Totals

While this increase in production may account for some of the increase in entrapped and stranded chinook, it is likely that this relatively small increase in spawning population does not account for the 98% increase in chinook found entrapped or stranded from 2004 to 2005. Much of this increase is due to water fluctuations at lower tailwater ranges during peak chinook emergence than occurred in previous years.

In 2005, tailwater levels during the middle part of April were lower than at the same time in 2004. Figure 18 is a comparison of tailwater levels and the number of chinook found either entrapped or stranded over the past two years. It appears that as a general trend when tailwater levels are low, more chinook are found entrapped. This may be attributed to the fact that most of the major entrapments form at lower tailwater levels. In 2005, one of these major entrapments, E501, contained over 6500 salmon.

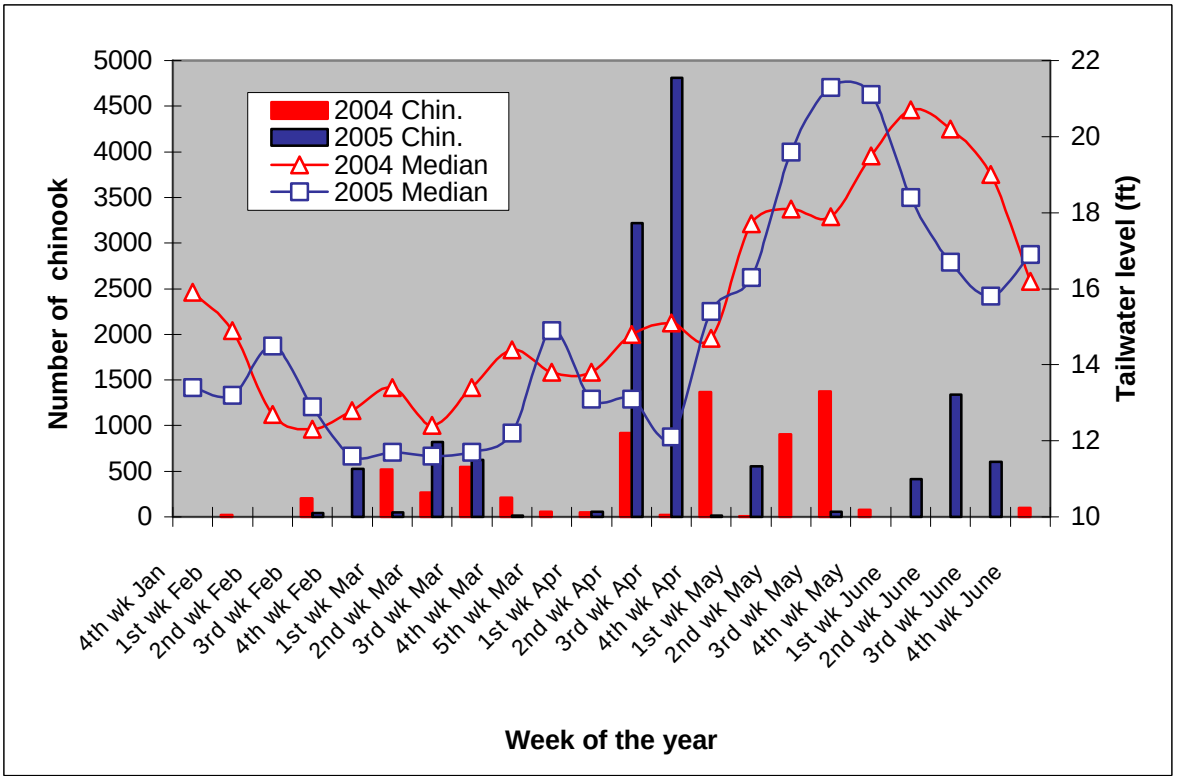

Figure 18: 2004 vs. 2005 Weekly Chinook Totals

The exact number of times E501 formed in 2005 is unknown due to the many variables that effect water levels in the study area, such as the flow at Bonneville Dam, the tidal stage, and the flow rate from tributaries of the Columbia, including nearby Hamilton and Hardy Creeks, and the Willamette River at Portland. However, with samplers actively covering the entire study area every one to three days throughout the juvenile emigration period and having done so with equal manpower and frequency in prior study years, one can assume that the number of times any given entrapment was sampled is representative of the number of times it formed and was filled with salmon.

E501 contained 6026 chinook in 2005, which accounted for 45.8% of all chinook sampled. E501 was sampled ten times in 2005 with the first and last sampling occurring on January 24 and April 20, respectively. In prior years, this entrapment was sampled only 4 to 6 times per year.

Peak numbers of chinook (5567) were pulled from this entrapment during a nine-day (April 10-18) period in mid-April. This period happened to overlap with peak chinook emergence April 15th to May 3rd. Chinook emergence timing appears to be relatively similar year to year, with the peak typically being the second week of April to the end of April. In previous years, E501 was not sampled until after April 12th due to increased spill from Bonneville Dam in the late spring to accommodate spring runoff and fish passage. The exception was 2001, where E501 was not sampled until March 29th and was last sampled on May 10th. This was a low water year, in which water was held back due to drought and hydropower concerns.

The last factor that may have contributed to an increase in the number of entrapped chinook in 2005 was simply chance. If chinook are utilizing shoreline rearing habitat near an entrapment or within a flooded entrapment, they are likely to be more susceptible to tailwater declines than chinook utilizing shorelines away from entrapment sites or deeper water rearing habitats. There are many factors that determine what is suitable rearing habitat, such as water temperature, water velocity, and food availability. There is no way to predict what rearing habitat chinook may be using on a given day due to the constantly changing habitat variables in the study area.

When compared to the 2004 study year, 2005 had a 66.6% decrease in the mortality rate of entrapped salmon (Table 9). However, this statistic is deceiving as 2005 had the most entrapped salmon of any of the past six years. When comparing just the raw total number of mortalities year to year, 2005 had the third highest total behind 2002 and 2004.

Table 9: Number of observed mortalities, including all stranded salmon whether found living or dead, per 100 entrapped or stranded salmon

	Chum	Chinook	Coho	Total
2001	9.5	6.4	2.8	5.9
2002	9.2	4.9	17	8.8
2003	1.6	1.5	4.2	2.2
2004	21.3	6.9	17.1	8.9
2005	0.9	1.1	4.8	1.3

The decrease in salmon mortality rate from 2004 to 2005 is primarily attributed to the lack of observed salmon stranding along the north shore of Pierce Island, which is where most salmon stranding occurred in past years. In 2005, only 31 salmon mortalities were observed due to stranding along the north shore of Pierce Island. This compares with 481 observed salmon mortalities due to stranding in that area in 2004. In 2004, the majority of salmon mortalities were attributed to two entrapments in that area, E510 and E511 (Figure 16). The combined mortalities retrieved from these two entrapments due to de-watering in 2004 were 74 chum, 224 chinook, and 65 coho. In 2005, no salmon mortalities were found in either of these entrapment sites.

71.9% of all observed salmon mortality in 2005 was found in one entrapment site (E507) (Figure 16). E507 floods via E508 and appears to require a tailwater elevation below 11.8 feet to de-water it. This entrapment flooded and de-watered on multiple occasions leaving a minimum of 128 salmon stranded. Another 63 live salmon that were pulled from this entrapment on February 21st would have been de-watered, if not for sampler intervention. Of the 191 either observed or projected mortalities, 3 were chum, 143 were chinook, and 43 were coho.

Future Plans

No attempt was made in 2005 to estimate the total impact to the salmon populations related to the number of entrapped and stranded salmonids found. There are two reasons that impacts could not be calculated. The first is a lack of a juvenile production estimate for any of the species spawning around Ives Island. To estimate production, one could use the population estimate, percentage of females, and average fecundity for each species to estimate fry

production. However, the one unknown is egg to fry survival rate and due to the rapidly changing environment below Bonneville dam, survival rates may vary dramatically. Without an egg to fry survival rate for this area, a production estimate would be a large range with no statistical validity. Past attempts to estimate egg to fry survival rates using redd caps have failed possibly due to the lateral substrate movement of the fry, sedimentation problems, and/or redd cap design. Future production estimate possibilities should be explored in order to assign annual impacts of juvenile salmonid entrapment and stranding below Bonneville Dam.

The other problem in calculating the impact of juvenile stranding is the estimate would be a minimum number. It is not possible to expand the sampled number of salmonids found entrapped and/or stranded to account for all flow fluctuations during the salmon emigration period because a random sampling protocol wasn't employed during sampling of the entrapments near Ives Island. Random sampling protocols similar to those employed in the Hanford Reach by Nugent et al. (2001) and Anglin et al. (2005) require the ability to predict the expected water level on a daily basis for a given area or entrapment. This has been relatively easy to do in the Hanford Reach, where water levels depend almost solely on the flow rate at Priest Rapids Dam and the distance below the dam. Predicting the water elevation for a given location is much more difficult in the Bonneville area, because it depends in a complex manner on the flow at Bonneville Dam, the tidal stage, and the flow rate from tributaries of the Columbia, including nearby Hamilton and Hardy Creeks, and the Willamette River at Portland. However, with six years worth of stranding data and a recently completed 3-D elevation model of the sampling area by US Fish and Wildlife Service (USFWS), a more complete picture of major entrapment events may be possible.

CONCLUSION

During the 2005 sampling period, 91.7% of the 14,337 sampled fish were chinook salmon, 4.5% were threatened chum salmon, and 3.8% were coho salmon. One hundred-seventy-six salmon were observed stranded (dewatered) of which 144 were chinook, 6 were chum, and 26 were coho.

When compared to the 2004 study year, 2005 had an 83% (6503) increase in the overall number of observed juvenile salmon found either entrapped or stranded. Numbers of entrapped or stranded chinook and chum increased by 97% (6498) and 2.1% (13), respectively. Numbers of entrapped or stranded coho decreased by 1.5% (8). Numbers of chum, chinook, and coho mortalities decreased by 95.4% (125), 67.1% (298), 72.3% (68), respectively.

Much of the increase in the overall number of entrapped salmon can be attributed to one entrapment, E501. This entrapment contained 6561 salmon in 2005. While E501 has been a major entrapment in previous years, the total number of salmon contained in that entrapment in 2005 was a 732% increase (5926 salmon) over any prior study years (Table 8).

The majority of the observed salmon mortality in 2005 came from one entrapment (E507) located just east of a bay which forms on the south central shore of Pierce Island (E508) (Figure 16). The total mortalities retrieved from E507, including those found stranded after E507 had drained, were 2 chum, 107 chinook, and 19 coho, or 71.9% of all known salmon mortalities.

This entrapment forms between tailwater elevations of 12.4 and 12.5 feet. However, the more critical tailwater measurement associated with this entrapment is for tailwater declines at elevations around 11.8 ft., as this causes the entrapment to dewater and strand any salmon contained within the entrapment (Table 5).

When entrapped and stranded salmon are combined, 94.4% of the threatened chum salmon observed were found in Areas D and E, the middle of Pierce Island and northern shoreline of Pierce Island, respectively. The majority (58.4%) of sampled chinook were found in Area E. Another 41.5% of the sampled chinook were split relatively evenly between the area around the mouth of Hamilton Creek (Area A), the floodplain that runs through Pierce Island (Area C), and Area D. The majority (49.2%) of sampled coho salmon were observed in Areas D, with another 23.8% and 25 % observed in Area A and E, respectively.

Since the beginning of 2001, 76.5% of the known chum mortalities and 68.8% of all known salmon mortalities were observed along the north shore of Pierce Island (Area E, Figure 1). Within the same time frame, 22.3% of the known chum mortalities and 16.4% of all known salmon mortalities were observed along the shorelines between Ives Island and the Pierce Ranch N.W.R. below Hamilton Creek (Area A).

The temperatures of entrapments known to contain any of the three species of juvenile salmon ranged from 44ºF to 74ºF (Table 6). Thermal mortalities did not play a role in the 2005 field season. The five chinook found dead in entrapments most likely died from dewatering prior to the arrival of the samplers, as the entrapments ranged from 42ºF to 69ºF.

During 2005, it is believed that dewatering caused 100% of total observed salmon mortality. Even though the majority of salmon found in this study were entrapped fish that were released back to the Columbia River alive, these fish still have the possibility of delayed mortality. Delayed mortality results from two primary sources, predation and altered fish behavior due to sub-lethal heat stress (Mesa and Weiland 1998). The extent of delayed mortality in the Ives Island area is unknown without any quantitative data.

Over eighty-three percent of all chum, 63.1% of all chinook, and 63.2% of all coho sampled during 2005 were retrieved from entrapments that were likely to have formed when Bonneville Dam tailwater levels dropped to elevations between 11.5 and 12.9 feet (Table 4).

Peak numbers of chum were sampled in mid-April when tailwater levels ranged between 11.6 and 15.6 feet. Peak numbers of chinook were sampled in mid-April when tailwater levels ranged between 11.6 and 15.6 feet. Peak numbers of coho were sampled during the last week of February, mid-March, and mid-April when tailwater elevations ranged between 11.4 and 14.3 feet, 11.5 and 15.3 feet, and 11.6 and 15.6 feet, respectively.

The fork length data indicate that the majority of the entrapped and stranded salmon are in the 35-50 mm range. Weekly fork length averages for chum did not exceed 50 mm until after May 1. The weekly mean and median fork lengths for chinook remained below 50 mm until the last part of May. Weekly fork length averages and medians for coho did not exceed 50 mm until the first part of June, with the exception of one week in mid-March. Stranded members of all three

salmon species found had mean fork lengths that were 8% to 30% shorter than those of their entrapped counterparts. These differences in mean fork length between entrapped and stranded salmon were significant at the 95% confidence level for chinook and coho ($p < 0.0005$), but not for chum. Fork lengths of stranded chum and coho never exceeded 51 mm and 42 mm, respectively. Stranded chinook were known to have fork lengths as long as 62 mm but fork lengths greater than 50 mm were rare. These findings appear to agree with the conclusions of Nugent et al. (2002) that show that salmonids are most likely to be impacted by river level fluctuations when they are small, however, it may to some degree reflect the fact that, when the salmon were smaller, river fluctuation levels exposed areas more likely to strand fish than later in the year when fish were larger.

The locations and characteristics of entrapments containing the majority of the observed juvenile salmon remain fairly constant from year to year. Changes in entrapment rankings appear to be more reflective of changes in prevailing tailwater levels than they are of changes in geography, vegetation, or fish behavior.

Data collected over the past six study years indicates that there are entrapments capable of entrapping large numbers of salmon as various tailwater levels. Avoiding specific tailwater ranges may not minimize the impact of juvenile stranding. The only way to substantially minimize the impact of stranding is to completely eliminate tailwater fluctuations or by steadily increasing the tailwater level throughout the juvenile emigration period.

Other options to reduce juvenile salmon mortality may include habitat improvements on Ives and Pierce Island to aid salmon in escaping large entrapments or filling in man-made entrapment areas formed during the fishwheel years of the early 1900's. Another possibility is minimizing tailwater fluctuations below Bonneville Dam during peak juvenile salmon emergence, typically mid-March through April.

ACKNOWLEDGEMENTS

This report and study would not have been possible without the help from many individuals. Rick Heitz with PSMFC, and Robert Brooks and Cameron Duff with ODFW provided additional field sampling. Steve VanderPloeg with WDFW provided assistance with GIS images. Ken Keller and Kelly Harlan with PSMFC who provided Ives Island population estimates for chum and chinook, respectively. Finally, Chris Murray with Pacific Northwest Laboratories (PNNL) who provided editorial assistance and statistical analysis.

REFERENCES

Anglin, D.R., and ten coauthors. 2005. Effects of hydropower operations on spawning habitat, rearing habitat and stranding/entrapment mortality of fall Chinook salmon in the Hanford Reach of the Columbia River. Final Draft Report dated April, 12, 2005, U.S. Fish and Wildlife Service,

Army Corps of Engineers. Bonneville Dam tailwater tables, 2000, 2001, 2002, 2003, 2004, 2005. Accessed January-July 2005. *http://www.nwdwc.usace.army.mil/cgibin/dataquery.pl?k=Bonneville+dam+Tail ater*

Bell, Milo C. 1973. Temperature- effects of fish, Fisheries Handbook of Engineering Requirements and Biological Criteria. Fisheries-Engineering Research Program, Corps Of Engineers, North Pacific Division, Portland, Oregon.

Brett, J. R. 1952. Temperature tolerance in young Pacific salmon, Genus *Oncorhynchus.* Fisheries Research Board of Canada, Journal, 9(6): 265-323

Chien, Yi-Ju and Murray, C. 2001. Evaluation of Chinook Salmon Entrapment near Ives Island in the Columbia River in 2000. Pacific Northwest National Laboratory.

Duston, R., and Jackman, B. 2002. 2001 Evaluation of Chum, Chinook, and Coho Entrapment near Ives Island in the Columbia River. Pacific States Marine Fisheries Commission, 2108 Grand Blvd., Vancouver, WA 98661

Duston, R., and Wilson, J. 2003. 2002 Evaluation of Chum, Chinook, and Coho Entrapment near Ives Island in the Columbia River. Pacific States Marine Fisheries Commission, 2108 Grand Blvd., Vancouver, WA 98661

Duston, R., and Wilson, J. 2004. 2003 Evaluation of Chum, Chinook, and Coho Entrapment near Ives Island in the Columbia River. Pacific States Marine Fisheries Commission, 2108 Grand Blvd., Vancouver, WA 98661

Donaldson and Cramer. 1971. Fishwheels of the Columbia. Binford and Mort, Publishers, Portland, Oregon, 97242.

Fish Passage Center. Hatchery Data, 2003. *http://www.fpc.org/Hatchery/Hatchery.htm*

Fish Passage Center. Ives Island Seining Data, 2005. Accessed July 27, 2005. http://www.fpc.org/spawning/seining/CHFseining_summary_2005.htm

Harlan, Kelly. 2005. Ives Island Adult Chinook Population Estimate. Pacific States Marine Fisheries Commission. Personal Communication on July 20, 2005.

Keller, Ken. 2005. Ives Island Adult Chum Population Estimate. Pacific States Marine Fisheries Commission. Personal Communication on July 17, 2005.

Mesa, Matthew G and Lisa K. Weiland. 1998. Effects of heat stress on the survival, predator avoidance ability, and physiology of juvenile fall chinook salmon. US Geological Survey, Biological Resources Division, Columbia River Research Laboratory, 5501A Cook-Underwood Rd., Cook, WA 98605.

NOAA Fisheries Service. Lower Columbia River Chum Salmon. Accessed August 29, 2005. www.nwr.noaa.gov/1salmon/salmesa/crithab/F-CHART-CMCOL.PDF

Nugent, J., T. Newsome, M. Nugent, W. Brock, P. Wagner, L. Key. 2001. 1998 Evaluation of Juvenile Fall Chinook Stranding on the Hanford Reach of the Columbia River. Washington Department of Fish and Wildlife. Prepared for The Bonneville Power Administration and the Public Utility District Number 2 of Grant County. BPA Contract Number 9701400 and GCPUD Contracts Document 97BI30417.

Nugent, J., T. Newsome, M. Nugent, W. Brock, P. Wagner, and P. Hoffarth. 2002. 1999 Evaluation of juvenile fall chinook salmon stranding on the Hanford Reach of the Columbia River. Washington Department of Fish and Wildlife. Prepared for The Bonneville Power Administration and the Public Utility District Number 2 of Grant County. BPA Contract Number 9701400 and GCPUD Contracts Document 97BI30417.

O.D.F.W./ P.S.M.F.C. 2005. Ives Island cumulative juvenile chum and chinook catch, 1999-2005. Accessed July 21, 2005. *1999-2006. http://www.fpc.org/ives_island/Graphs_of_cum_catch.htm*

Page, T.L. 1976. Observation on juvenile salmon stranding in the Columbia River, April 1976. Report of Battelle Pacific Northwest Laboratory to United Engineers and Contractors for Washington Public Water Supply System, Richland, Washington.

Phinney, L.A. 1974a. Further observations on juvenile salmon stranding in the Skagit River, March 1973. Washington Department of Fisheries.

Phinney, L.A. 1974b. Report on the 1972 study of the effect of river flow fluctuations below Merwin Dam on downstream migrant salmon. Washington Department of Fisheries.

Thompson, J.S. 1970. Skagit River fry mortality study, March 1969. Washington Department of Fish and Game

Tipping, J., P. Buckley, and J. Danielson. 1978. Cowlitz River steelhead spawning and fry stranding study, 1977-1978. Progress report. Washington Department of Game.

van der Nald W., R. Clark, and B. Spellman. 2000. 1998-1999 Evaluation of Fall Chinook and Chum Salmon Spawning Below Bonneville, The Dalles, John Day and McNary Dams. O.D.F.W. 2501 S.W. First Avenue, Box 59, Portland, OR 97207.

van der Nald W., R. Clark, and B. Spellman. 2001. 1999-2000 Evaluation of Fall Chinook and Chum Salmon Spawning Below Bonneville, The Dalles, John Day and McNary Dams. O.D.F.W. 2501 S.W. First Avenue, Box 59, Portland, OR 97207.

van der Nald W., R. Clark, and Spellman. 2002. 2000-2001 Evaluation of Fall Chinook and Chum Salmon Spawning Below Bonneville, The Dalles, John Day and McNary Dams. O.D.F.W. 2501 S.W. First Avenue, Box 59, Portland, OR 97207.

van der Nald W., R. Clark, and B. Spellman. 2003. 2001-2002 Evaluation of Fall Chinook and Chum Salmon Spawning Below Bonneville, The Dalles, John Day and McNary Dams. O.D.F.W. 2501 S.W. First Avenue, Box 59, Portland, OR 97207.

van der Nald, Clark R., Brooks, R. and Duff, C. 2004. 2002-2003 Evaluation of Fall Chinook and Chum Salmon Spawning Below Bonneville Dam. O.D.F.W. 2501 S.W. First Avenue, Box 59, Portland, OR 97207.

van der Nald, Duff, C. and Brooks, R. 2005. 2003-2004 Evaluation of Fall Chinook and Chum Salmon Spawning Below Bonneville Dam. O.D.F.W. 2501 S.W. First Avenue, Box 59, Portland, OR 97207.

WRCC (Western Regional Climate Center). Bonneville Dam, Oregon. Accessed June 15, 2004. *http://www.wrcc.dri.edu/cgi-bin/cliMAIN.pl?orbonn*

Appendix A: Site Coordinates

TABLE A. Year 2005 entrapment locations found near Ives Island on the Columbia River. Coordinates are listed in datum NAD 27.

Entrapment Locations				Sampling
Entrapment Code	Species Sampled	Latitude	Longitude	Area
E501	chinook, coho, chum	+45.6246990	-122.0059570	E
E502	chinook	+45.6192290	-122.0020450	B
E503	chinook, coho, chum	+45.6263940	-121.9925430	A
E504	chinook, coho, chum	+45.6246510	-122.0073550	E
E505	chinook	+45.6245810	-122.0036170	E
E506	chinook	+45.6212700	-121.9992500	B
E507	chinook, coho, chum	+45.6210460	-122.0091310	D
E508	chinook, coho, chum	+45.6208980	-122.0096850	D
E509		+45.6245900	-122.0036680	E
E510	chinook	+45.6246380	-122.0050660	E
E511	chinook, chum	+45.6245500	-122.0052980	E
E512	chinook	+45.6263000	-121.9944400	A
E513	chinook, chum	+45.6260810	-121.9930460	A
E514	chinook, coho, chum	+45.6207980	-122.0044410	C
E515	chinook	+45.6216860	-122.0030140	C
E516	chinook	+45.6229320	-122.0086110	E
E517		+45.6213610	-121.9993780	B
E518	chinook, coho	+45.6276570	-121.9950760	A
E519	chinook, coho	+45.6241080	-121.9947230	A
E520		+45.6245490	-122.0048030	E
HTE501	chinook	+45.5912710	-122.0779350	Horsetail

TABLE B. Year 2005 stranding locations found near Ives Island on the Columbia River. Coordinates are listed in datum NAD 27.

Stranding Locations				Sampling
Entrapment Code	Species Sampled	Latitude	Longitude	Area
S501	chinook	+45.6192100	-122.0022100	B
S502	chinook	+45.6254600	-121.9961	A
S503	chinook, coho	+45.6149780	-122.0277710	F
S504	chinook	+45.6210460	-122.0091310	D
S505	chinook, coho	+45.6202140	-122.0096850	D
S506	chinook, coho, chum	+45.6210460	-122.0091310	D
S507	chinook, coho	+45.6213670	-121.9984540	B
S508	chinook	+45.6257760	-121.9961690	A
S509	chinook	+45.6245820	-122.0036110	E
S510	chinook, coho, chum	+45.6245460	-122.0047980	E
S511	chinook	+45.6255750	-121.9948890	A
S512	chinook	+45.6245260	-122.0066330	E
S513	chinook, chum	+45.6243510	-122.0051610	E
S514	chum	+45.6248670	-122.0065750	E
S515	chinook	+45.6212890	-121.9998530	B
S516	chinook	+45.6267210	-121.9952020	A
S517	chinook	+45.6236120	-122.0082010	E
S518	chinook	+45.6226990	-122.0087940	E
HTS501	chinook	+45.5911800	-122.0778470	Horsetail
HTS502	coho	+45.5911890	-122.0778340	Horsetail

Appendix B: Tables

Table B1: Weekly sampling results of threatened chum salmon, 2005

Week Ending	Stranded		Entrapped		Total Mortalities (Stranded + Entrapped)	Total Chum
	Mortality	Alive	Mortality	Alive		
02/26/2005	0	0	0	1	0	1
03/05/2005	0	0	0	2	0	2
03/12/2005	0	0	0	22	0	22
03/19/2005	2	0	0	42	2	44
03/26/2005	0	0	0	0	0	0
04/02/2005	0	0	0	0	0	0
04/09/2005	2	0	0	2	2	4
04/16/2005	0	0	0	280	0	280
04/23/2005	0	0	0	290	0	290
04/30/2005	2	0	0	0	2	2
05/07/2005	0	0	0	1	0	1
Total	**6**	**0**	**0**	**640**	**6**	**646**

Table B2. Results of weekly sampling of chinook salmon, 2005

Week Ending	Stranded		Entrapped		Total Mortalities (Stranded + Entrapped)	Total Chinook
	Mortality	Alive	Mortality	Alive		
01/29/2005	1	1	1	0	2	3
02/05/2005	0	0	0	3	0	3
02/12/2005	0	0	1	2	1	3
02/19/2005	0	0	1	39	1	40
02/26/2005	37	0	0	492	37	529
03/05/2005	0	0	0	51	0	51
03/12/2005	1	0	0	820	1	821
03/19/2005	67	0	0	557	67	624
03/26/2005	2	0	2	8	4	12
04/02/2005	0	0	0	0	0	0
04/09/2005	15	2	0	37	15	54
04/16/2005	0	0	0	3219	0	3219
04/23/2005	1	0	0	4812	1	4813
04/30/2005	12	0	0	0	12	12
05/07/2005	1	0	0	554	1	555
05/14/2005	0	0	0	0	0	0
05/21/2005	3	0	0	53	3	56
05/28/2005	0	0	0	0	0	0
06/04/2005	0	0	0	415	0	415
06/11/2005	1	0	0	1337	1	1338
06/18/2005	0	0	0	602	0	602
Total	**141**	**3**	**5**	**13001**	**146**	**13150**

Table B3. Results of weekly sampling of coho salmon, 2005

Week Ending	Stranded		Entrapped		Total Mortalities (Stranded + Entrapped)	Total Coho
	Mortality	Alive	Mortality	Alive		
01/29/2005	0	0	0	0	0	0
02/05/2005	0	0	0	1	0	1
02/12/2005	0	0	0	0	0	0
02/19/2005	0	0	0	7	0	7
02/26/2005	10	0	0	109	10	119
03/05/2005	0	0	0	15	0	15
03/12/2005	0	0	0	84	0	84
03/19/2005	12	0	0	61	12	73
03/26/2005	2	0	0	0	2	2
04/02/2005	0	0	0	0	0	0
04/09/2005	2	0	0	0	2	2
04/16/2005	0	0	0	45	0	45
04/23/2005	0	0	0	63	0	63
04/30/2005	0	0	0	0	0	0
05/07/2005	0	0	0	2	0	2
05/14/2005	0	0	0	0	0	0
05/21/2005	0	0	0	0	0	0
05/28/2005	0	0	0	0	0	0
06/04/2005	0	0	0	0	0	0
06/11/2005	0	0	0	40	0	40
06/18/2005	0	0	0	88	0	88
Total	**26**	**0**	**0**	**515**	**26**	**541**

Table B4. Maximum continuous tailwater declines during the 24-hour periods immediately preceding the sampling of juvenile salmon mortality including all stranded salmon whether found living or dead. Site codes beginning with E are entrapments; those beginning with S are strandings. (*) Denotes fish that would have become dewatered.

Site Code	Date	Max. continuous decline in tailwater during the prev. 24 hrs (ft)	Chum Morts	Chinook Morts	Coho Morts	Live Chum	Live Chinook	Live Coho
HTS501	3/7/05	11.8-11.5	0	1	0	0	0	0
HTS502	3/20/05	13.7-11.4	0	0	1	0	0	0
S501	1/24/05	13.4-11.9	0	1	0	0	0	0
S502	1/25/05	13.1-11.9	0	0	0	0	1	0
S503	2/21/05	12.1-11.5	0	1	3	0	0	0
S504	2/23/05	11.8-11.5	0	36	7	0	0	0
S505	3/6/05	13.7-12.5	0	1	0	0	0	0
S506	3/16/05	11.8-11.5	2	67	12	0	0	0
S507	3/20/05	13.7-11.5	0	1	1	0	0	0
S508	3/21/05	12.2-12.0	0	1	0	0	0	0
S509	4/3/05	15.4-13.3	0	0	0	0	*2	0
S510	4/3/05	15.4-13.3	2	14	2	0	0	0
S511	4/3/05	15.4-13.3	0	1	0	0	0	0
S512	4/17/05	12.6-11.9	0	1	0	0	0	0
S513	4/24/05	14.7-13.5	1	10	0	0	0	0
S514	4/24/05	14.7-13.5	1	0	0	0	0	0
S515	4/24/05	14.7-13.5	0	1	0	0	0	0
S516	5/105	15.6-14.6	0	1	0	0	0	0
S517	5/15/05	20.9-18.6	0	3	0	0	0	0
S518	6/6/05	17.5-16.0	0	1	0	0	0	0
E502	1/24/05	13.4-11.9	0	1	0	0	0	0
E502-2	2/14/05	12.7-11.9	0	1	0	0	0	0
E506	2/11/05	15.2-13.1	0	1	0	0	0	0
E507-2	2/21/05	12.1-11.5	0	0	0	*1	*36	*26
E507-4	3/20/05	13.7-11.5	0	2	0	0	0	0
E510	4/3/05	15.4-13.3	0	0	0	0	*2	0
E511	4/3/05	15.4-13.3	0	0	0	*1	*6	0
E513	4/3/05	15.4-13.3	0	0	0	*1	*23	0

Table B5. Fork length summary of entrapped chum salmon, 2005

Week Ending	Number of Chum	Number of Chum Measured	Fork Length			
			Median	Mean	Minimum	Maximum
02/26/2005	1	2	41	41	41	41
03/05/2005	2	2	40	40	35	45
03/12/2005	22	22	42	42.4	37	48
03/19/2005	42	42	43	41	37	49
03/26/2005	0	0				
04/02/2005	0	0				
04/09/2005	2	2	40.5	40.5	40	41
04/16/2005	280	133	49	49	39	61
04/23/2005	290	271	47	48	36	64
04/30/2005	0	0				
05/07/2005	1	1	56	56	56	56

Table B6. Fork Length summary of entrapped chinook salmon, 2005

Week Ending	Number of Chin	Number of Chin Measured	Fork Length			
			Median	Mean	Minimum	Maximum
01/29/2005	1	1	37	37	37	37
02/05/2005	3	3	39	40.3	39	43
02/12/2005	3	3	41	42.3	38	41
02/19/2005	40	40	42	44	36	58
02/26/2005	492	250	43	43.7	35	64
03/05/2005	51	51	46	47	37	59
03/12/2005	820	244	46	48	35	71
03/19/2005	557	349	41	44.4	36	71
03/26/2005	10	10	39.5	40.1	38	43
04/02/2005	0	0				
04/09/2005	37	37	41	41	37	43
04/16/2005	3219	237	42	43	37	61
04/23/2005	4812	682	43	44	35	76
04/30/2005	0	0				
05/07/2005	554	209	45	45.7	37	58
05/14/2005	0	0				
05/21/2005	53	53	53	53.5	38	85
05/28/2005	0	0				
06/04/2005	415	118	51	53.6	37	82
06/11/2005	1337	506	60	60.5	40	85
06/18/2005	602	282	76.5	77.6	54	117

Table B7. Fork Length summary of entrapped coho salmon, 2005

Week Ending	Number of Coho	Number of Coho Measured	Fork Length			
			Median	Mean	Minimum	Maximum
01/29/2005	0	0				
02/05/2005	1	1	43	43	43	43
02/12/2005	0	0				
02/19/2005	7	7	36	36	34	38
02/26/2005	109	109	40	48	34	114
03/05/2005	15	15	40	39	36	43
03/12/2005	84	84	39	41	35	51
03/19/2005	61	61	39	51	35	128
03/26/2005	0	0				
04/02/2005	0	0				
04/09/2005	0	0				
04/16/2005	45	45	38	38	34	46
04/23/2005	63	63	39	42	33	105
04/30/2005	0	0				
05/07/2005	2	2	46	46	42	49
05/14/2005	0	0				
05/21/2005	0	0				
05/28/2005	0	0				
06/04/2005	0	0				
06/11/2005	40	40	75	76	64	98
06/18/2005	88	88	76.5	77.6	54	117

Table B8. Observed fork length summary of threatened chum salmon at stranding sites near Ives Island in 2005.

Week Ending	Number of Chum	Number of Chum Measured	Fork Length			
			Median	Mean	Minimum	Maximum
03/19/2005	2	2	41.5	41.5	40	43
03/26/2005	0	0				
04/02/2005	0	0				
04/09/2005	2	2	47	47	43	51
04/16/2005	0	0				
04/23/2005	0	0				
04/30/2005	2	2	43	43	42	44

Table B9. Observed fork length summary of chinook salmon at stranding sites near Ives Island in 2005.

Week Ending	Number of Chin	Number of Chin Measured	Fork Length			
			Median	Mean	Minimum	Maximum
01/29/2005	2	2	37	37	37	37
02/05/2005	0	0				
02/12/2005	0	0				
02/19/2005	0	0				
02/26/2005	37	37	40	41.5	37	52
03/05/2005	0	0				
03/12/2005	1	1	52	52	52	52
03/19/2005	67	67	40	40.2	35	55
03/26/2005	2	2	42.5	42.5	41	44
04/02/2005	0	0				
04/09/2005	17	17	41	42.4	37	60
04/16/2005	0	0				
04/23/2005	1	1	47	47	47	47
04/30/2005	12	12	46	45.5	40	50
05/07/2005	1	1	42	42	42	42
05/14/2005	0	0				
05/21/2005	3	3	47	49.7	40	62
05/28/2005	0	0				
06/04/2005	0	0				
06/11/2005	1	1	48	48	48	48
06/18/2005	0	0				

Table B10. Observed fork length summary of coho salmon at stranding sites near Ives Island in 2005.

Week Ending	Number of Coho	Number of Coho Measured	Fork Length			
			Median	Mean	Minimum	Maximum
02/26/2005	10	10	37	36.8	32	42
03/05/2005	0	0				
03/12/2005	0	0				
03/19/2005	12	12	37.5	37.1	31	40
03/26/2005	2	2	38.5	38.5	38	39
04/02/2005	0	0				
04/09/2005	2	2	37	37	34	40

Key to dominant substrate codes. After (Nugent et al. 2002)

Code	Substrate Class
1	Fines: clay to coarse sand (<1 mm)
2	Very coarse sand (1-2 mm)
3	Fine gravel (2-4 mm)
4	Medium gravel (4-8 mm)
5	Coarse gravel (8-16 mm)
6	Small pebble (16-32 mm)
7	Large pebble (32-64 mm)
8	Cobble or rubble (64-256 mm)
9	Boulder (>256 mm)

Table B11. Number of entrapped chum salmon found on sites marked by a particular dominant substrate near Ives Island in 2005. Numbers in ( ) represent mortalities.

Site Code	Substrate Codes		
	1	5	7
E507-2	1		
E501-3		1	
E504	1		
E508-3	17		
E501-4		5	
E501-5		6	
E504-2	4		
E508-4	25		
E501-6		7	
E511			1
E513			1
E501-8		251	
E504-3	29		
E501-9		129	
E503-9			34
E504-4	30		
E508-5	89		
E501-10		8	
E514		1	
Total Number	**196**	**408**	**36**
Mean Number per Site	**24.5**	**51**	**12**
Median Number per Site	**21**	**6.5**	**1**

Table B12. Number of stranded chum salmon found on sites marked by a particular dominant substrate near Ives Island in 2005. Accompanying entrapment codes identify the stranding site as a dewatered entrapment. Numbers in ( ) represent mortalities (key precedes Table B11).

Site Code	Substrate Codes		
	1	5	6
S506	2 (2)		
S510			2 (2)
S513			1 (1)
S514		1 (1)	
Total Number	**2 (2)**	**1 (1)**	**3 (3)**
Mean Number per Site	**2**	**1**	**1.5**
Median Number per Site	**2**	**1**	**1.5**

Table B13. Number of entrapped chinook salmon found on sites marked by a particular dominant substrate near Ives Island in 2005. Numbers in ( ) represent mortalities (key precedes Table B11).

Site Code	Substrate Codes				
	1	5	6	7	8
E502				1 (1)	
E501-2		3			
E505			1		
E505-2			1		
E506			1 (1)		
E502-2				1 (1)	
E507	39				
E507-2	36				
E503				27	
E508	359				
E503-2				13	
E508-2	57				
E501-3		51			
E508-3	677				
E507-3	2				
E501-4		137			
E501-5		63			
E504-2	48				
E508-4	415				
E501-6		31			
E507-4	2 (2)				
E501-7		2			
E503-3				6	
E510		2			
E511				6	
E512					6
E513				23	
E501-8		2666			
E504-3	553				
E501-9		2901			
E503-9				562	
E504-4	407				
E508-5	770				
E501-10		172			
E514		466			
E515	39				
E510-2		25			
E514-2		24			
E516-2	53				
E516-3	415				
E516-4	113				
E518					305
E514-3		763			
E514-4		156			
E514-5		185			
E518-2					81
E519	336				
HTE501	4				
Total Number	**4323 (2)**	**7647**	**3 (1)**	**639 (2)**	**392**
Mean Number per Site	**240.3**	**477.9**	**1.0**	**79.9**	**130.7**
Median Number per Site	**85.0**	**100.0**	**1.0**	**9.5**	**81.0**

Table B14. Number of stranded chinook salmon found on sites marked by a particular dominant substrate near Ives Island in 2005. Accompanying entrapment codes identify the stranding site as a dewatered entrapment. Numbers in ( ) represent mortalities (key precedes Table B11).

Site Code	Substrate Codes				
	1	5	6	7	8
S501				1 (1)	
S502			1 (1)		
S503	1 (1)				
S504	36 (36)				
S505	1 (1)				
S506	67 (67)				
S507				1 (1)	
S508					1 (1)
S509			2		
S510			14 (14)		
S511				1 (1)	
S512		1 (1)			
S513			10 (10)		
S515		1 (1)			
S516				1 (1)	
S517	3 (3)				
S518		1 (1)			
HTS501	1 (1)				
Total Number	**109 (109)**	**3 (3)**	**27 (25)**	**4 (4)**	**1 (1)**
Mean Number per Site	**18.2**	**1**	**6.8**	**1**	**1**
Median Number per Site	**2**	**1**	**6**	**1**	**1**

Table B15. Number of entrapped coho salmon found on entrapment sites marked by a particular dominant substrate near Ives Island in 2005. Numbers in ( ) represent mortalities (key precedes Table B11).

Site Code	Substrate Codes			
	1	5	7	8
E501-2		1		
E507	7			
E507-2	26			
E503			2	
E508	56			
E508-2	25			
E501-3		15		
E508-3	68			
E501-4		16		
E501-5		3		
E508-4	54			
E501-6		4		
E501-8		42		
E504-3	3			
E501-9		46		
E503-9			3	
E504-4	2			
E508-5	11			
E501-10		1		
E514		2		
E518				40
E514-5		4		
E518-2				15
E519	69			
Total Number	**321**	**134**	**5**	**55**
Mean Number per Site	**32.1**	**13.4**	**2.5**	**27.5**
Median Number per Site	**25.5**	**4**	**2.5**	**27.5**

Table B16. Number of stranded coho salmon found on sites marked by a particular dominant substrate near Ives Island in 2005. Accompanying entrapment codes identify the stranding site as a dewatered entrapment. Numbers in ( ) represent mortalities (key precedes Table B11).

Site Code	Substrate Codes		
	1	6	7
S503	3 (3)		
S504	7 (7)		
S506	12 (12)		
S507			1 (1)
S510		2 (2)	
HTS502	1 (1)		
Total Number	**23 (23)**	**2 (2)**	**1 (1)**
Mean Number per Site	**5.8**	**2**	**1**
Median Number per Site	**5**	**2**	**1**

Key to embeddedness codes (After Nugent et al. 2002):

Code	% Fines	Description
1	0-25	Openings between dominant sized particles are 1/3 to 1/2 the size of the particles. Few fines in between. Edges are clearly discernible.
2	25-50	Openings are apparent, but <1/4 the size of the particles. Edges are discernible, but up to half obscured.
3	50-75	Openings are completely filled, but half of edges are still discernible.
4	75-100	All openings are obscured. Only one or two edges discernible and size cannot be determined without removal.

Table B17. Number of threatened chum salmon found at entrapment sites with a given substrate embeddedness near Ives Island of the Columbia River in 2005. Numbers in ( ) represent mortalities.

Site Code	Embeddedness Code			
	1	2	3	4
E507-2				1
E501-3		1		
E504			1	
E508-3				17
E501-4		5		
E501-5		6		
E504-2			4	
E508-4				25
E501-6		7		
E511		1		
E513	1			
E501-8		251		
E504-3			29	
E501-9		129		
E503-9		34		
E504-4			30	
E508-5				89
E501-10		8		
E514		1		
Total number	**1**	**443**	**64**	**132**
Mean number per site	**1**	**44.3**	**16**	**33**
Median number per site	**1**	**6.5**	**16.5**	**21**

Table B18. Number of threatened chum salmon found at stranding sites with a given substrate embeddedness near Ives Island of the Columbia River in 2005. Accompanying entrapment codes identify the stranding site as a dewatered entrapment. Numbers in ( ) represent mortalities (key precedes Table B17).

Site Code	Embeddedness Code			
	1	2	3	4
S506	0			2 (2)
S510	0	2 (2)		
S513	0		1 (1)	
S514	0		1 (1)	
Total number	**0**	**2 (2)**	**2 (2)**	**2 (2)**
Mean number per site	**0**	**2**	**1**	**2**
Median number per site	**0**	**2**	**1**	**2**

Table B19. Number of chinook salmon found at entrapment sites with given substrate embeddedness near Ives Island of the Columbia River in 2005. Numbers in ( ) represent mortalities (key precedes Table B17).

Site Code	Embeddedness Code			
	1	2	3	4
E502		1 (1)		
E501-2		3		
E505		1		
E505-2		1		
E506	1 (1)			
E502-2		1 (1)		
E507				39
E507-2				36
E503		27		
E508				359
E503-2		13		
E508-2				57
E501-3		51		
E508-3				677
E507-3				2
E501-4		137		
E501-5		63		
E504-2			48	
E508-4				415
E501-6		31		
E507-4				2 (2)
E501-7		2		
E503-3		6		
E510		2		
E511		6		
E512	6			
E513	23			
E501-8		2666		
E504-3			553	
E501-9		2901		
E503-9		562		
E504-4			407	
E508-5				770
E501-10		172		
E514		466		
E515				39
E510-2		25		
E514-2		24		
E516-2				53
E516-3				415
E516-4				113
E518	305			
E514-3		763		
E514-4		156		
E514-5		185		
E518-2	81			
E519				336
HTE501				4
Total number	**416**	**8265**	**1008**	**3317**
Mean number per site	**83.2**	**330.6**	**336**	**221.1**
Median number per site	**23**	**27**	**407**	**57**

Table B20. Number of chinook salmon found at stranding sites with given substrate embeddedness near Ives Island of the Columbia River in 2005. Accompanying entrapment codes identify the stranding site as a dewatered entrapment. Numbers in ( ) represent mortalities (key precedes Table B17).

Site Code	Embeddedness Code			
	1	2	3	4
S501			1 (1)	
S502		1 (1)		
S503				1 (1)
S504				36 (36)
S505				1 (1)
S506				67 (67)
S507	1 (1)			
S508		1 (1)		
S509		2		
S510		14		
S511		1 (1)		
S512		1 (1)		
S513			10 (10)	
S515		1 (1)		
S516	1 (1)			
S517				3 (3)
S518		1(1)		
HTE501				1 (1)
Total number	**2 (2)**	**22 (6)**	**11 (11)**	**109 (109)**
Mean number per site	**1**	**2.8**	**5.5**	**18.2**
Median number per site	**1**	**1**	**5.5**	**2**

Table B21. Number of coho salmon found at entrapment sites with given substrate embeddedness near Ives Island of the Columbia River in 2005. Numbers in ( ) represent mortalities (key precedes Table B17).

Site Code	Embeddedness Code			
	1	2	3	4
E501-2		1		
E507				7
E507-2				26
E503		2		
E508				56
E508-2				25
E501-3		15		
E508-3				68
E501-4		16		
E501-5		3		
E508-4				54
E501-6		4		
E501-8		42		
E504-3			3	
E501-9		46		
E503-9		3		
E504-4			2	
E508-5				11
E501-10		1		
E514		2		
E518	40			
E514-5		4		
E518-2	15			
E519				69
Total number	**55**	**139**	**5**	**316**
Mean number per site	**27.5**	**11.6**	**2.5**	**39.5**
Median number per site	**27.5**	**3.5**	**2.5**	**40.0**

Table B22. Number of coho salmon found at stranding sites with given substrate embeddedness near Ives Island of the Columbia River in 2005. Accompanying entrapment codes identify the stranding site as a dewatered entrapment. Numbers in ( ) represent mortalities (key precedes Table B17).

Site Code	Embeddedness Code			
	1	2	3	4
S503				3 (3)
S504				7 (7)
S506				12 (12)
S507	1 (1)			
S510		2 (2)		
HTE502				1 (1)
Total number	**1 (1)**	**2 (2)**	**0**	**23 (23)**
Mean number per site	**1**	**2**	**0**	**5.8**
Median number per site	**1**	**2**	**0**	**5**

Vegetation density codes (After Nugent et al. 2002):

Code	Description
0	No vegetation present
1	Sparse vegetation, substrate is completely evident.
2	Medium vegetation, substrate is only partially obscured.
3	Dense vegetation, substrate is nearly or completely obscured.

Table B23. Number of threatened chum salmon observed at entrapment sites with given vegetation densities near Ives Island of the Columbia River in 2005. Numbers in ( ) represent mortalities.

Site Code	Vegetation Density Code			
	0	**1**	**2**	**3**
E507-2		1		
E501-3		1		
E504		1		
E508-3		17		
E501-4		5		
E501-5		6		
E504-2		4		
E508-4		25		
E501-6		7		
E511		1		
E513	1			
E501-8		251		
E504-3		29		
E501-9		129		
E503-9	34			
E504-4		30		
E508-5		89		
E501-10		8		
E514		1		
Total Number	**35**	**605**	**0**	**0**
Mean Number per Site	**17.5**	**35.6**	**0**	**0**
Median Number per Site	**17.5**	**7**	**0**	**0**

Table B24. Number of threatened chum salmon observed at stranding sites with given vegetation densities near Ives Island of the Columbia River in 2005. Accompanying entrapment codes identify the stranding site as a dewatered entrapment (key precedes Table B23). Numbers in ( ) represent mortalities.

Site Code	Vegetation Density Code			
	0	1	2	3
S506		2 (2)		
S510		2 (2)		
S513			1 (1)	
S514		1 (1)		
Total Number	**0**	**5 (5)**	**1 (1)**	**0**
Mean Number per Site	**0**	**1.7**	**1**	**0**
Median Number per Site	**0**	**2**	**1**	**0**

Table B25. Number of chinook salmon observed at entrapment sites with given vegetation densities near Ives Island of the Columbia River in 2005. Numbers in ( ) represent mortalities (key precedes Table B23).

Site Code	Vegetation Density Code			
	0	1	2	3
E502		1 (1)		
E501-2		3		
E505		1		
E505-2		1		
E506		1 (1)		
E502-2		1 (1)		
E507		39		
E507-2		36		
E503	27			
E508		359		
E503-2	13			
E508-2		57		
E501-3		51		
E508-3		677		
E507-3		2		
E501-4		137		
E501-5		63		
E504-2		48		
E508-4		415		
E501-6		31		
E507-4		2 (2)		
E501-7		2		
E503-3	6			
E510		2		
E511		6		
E512		6		
E513	23			
E501-8		2666		
E504-3		553		
E501-9		2901		
E503-9	562			
E504-4		407		
E508-5		770		
E501-10		172		
E514		466		
E515	39			
E510-2		25		
E514-2		24		
E516-2				53
E516-3				415
E516-4				113
E518				305
E514-3		763		
E514-4		156		
E514-5		185		
E518-2				81
E519			336	
HTE501		4		
Total Number	**670**	**11033**	**336**	**967**
Mean Number per Site	**111.7**	**306.5**	**336**	**193.4**
Median Number per Site	**25**	**43.5**	**336**	**113**

Table B26. Number of chinook salmon observed at stranding sites with given vegetation densities near Ives Island of the Columbia River in 2005. Accompanying entrapment codes identify the stranding site as a dewatered entrapment (key precedes Table B23). Numbers in ( ) represent mortalities.

Site Code	Vegetation Density Code			
	0	1	2	3
S501		1 (1)		
S502	1 (1)			
S503				1 (1)
S504		36 (36)		
S505	1 (1)			
S506		67 (67)		
S507	1 (1)			
S508	1 (1)			
S509		2		
S510		14 (14)		
S511		1 (1)		
S512		1 (1)		
S513			10 (10)	
S515		1 (1)		
S516		1 (1)		
S517		3 (3)		
S518		1 (1)		
HTS501		1(1)		
Total Number	**4 (4)**	**129 (127)**	**10 (10)**	**1 (1)**
Mean Number per Site	**1**	**10.8**	**10**	**1**
Median Number per Site	**1**	**1**	**10**	**1**

Table B27. Number of coho salmon observed at entrapment sites with given vegetation densities near the Ives Island of the Columbia River in 2005. Numbers in ( ) represent mortalities (key precedes Table B23).

Site Code	Embeddedness Code			
	1	2	3	4
E501-2		1		
E507				7
E507-2				26
E503		2		
E508				56
E508-2				25
E501-3		15		
E508-3				68
E501-4		16		
E501-5		3		
E508-4				54
E501-6		4		
E501-8		42		
E504-3			3	
E501-9		46		
E503-9		3		
E504-4			2	
E508-5				11
E501-10		1		
E514		2		
E518	40			
E514-5		4		
E518-2	15			
E519				69
Total number	**55**	**139**	**5**	**316**
Mean number per site	**27.5**	**11.6**	**2.5**	**39.5**
Median number per site	**27.5**	**3.5**	**2.5**	**40.0**

Table B28. Number of coho salmon observed at stranding sites with given vegetation densities near the Ives Island of the Columbia River in 2005. Accompanying entrapment codes identify the stranding site as a dewatered entrapment. Numbers in ( ) represent mortalities (key precedes Table B23).

Site Code	Vegetation Density Code			
	0	1	2	3
S503				3 (3)
S504		7 (7)		
S506		12 (12)		
S507	1 (1)			
S510		2 (2)		
HTS502		1 (1)		
Total Number	**1 (1)**	**22 (22)**	**0**	**3 (3)**
Mean Number per Site	**1**	**5.5**	**0**	**3**
Median Number per Site	**1**	**4.5**	**0**	**3**

Table B29. Chinook mortalities and temperature measurements

Sampling Date	Entrapment Code	Mortalities	Projected Mortalities	Air Temp. (F)	River Temp. (F)	Entrapment Temp. (F)
1/24/05	E502	1	0	46	41	48
2/11/05	E506	1	0	45	40	46
2/14/05	E502-2	1	0	42	41	51
3/20/05	E507-4	2	0	54	48	56

Appendix C. Post Seining Report

Post Juvenile Seining Report, 2005.
Below the Dams Project 1999-003-01.

The objective of post seining for the Below the Dams project (BTD) is to determine a general abundance/production and rearing time of wild juvenile fall chinook produced below Bonneville Dam.

Abundance estimates were made based on average fecundity of the upriver bright stock (URB) of chinook adults at the Bonneville Hatchery. Genetic samples indicate that the chinook spawning below Bonneville Dam are similar to the bright stock at the Bonneville Hatchery, Little White Salmon Hatchery, and the Yakima River fall chinook (Anne Marshall). The average fecundity of females at Bonneville Hatchery is 4,500 (Cameron Duff, pers. comm.). The estimated number of females spawning below Bonneville Dam in 2004 was 924. Based on average fecundity and estimated number of females a potential of 4,158,000 eggs were deposited.

Egg to fry survival rate was based on Duncan Creeks' naturally spawning chum salmon. This is the closest proximity of a naturally spawning salmon population that is monitored to the Ives Island population. The highest egg to fry survival rate for Duncan Creek chum was 60% with an average survival rate of 40.1% from 2002 – 2005 (Todd Hillson, pers. comm.). Based on these survival rates, the juvenile chinook egg to fry survival ranged from 2,494,800 (60% survival) to 1,667,358 (40.1% survival).

The BTD coded wire tagging effort began on April 22 and ended on May 27. Fish were captured using beach and stick seines. Coded wire tags (CWT's), unique to the BTD project, were implanted into 32,642 juvenile chinook. Chinook ranging in size from 47-65mm were tagged. The fish were adipose clipped to identify the presence of CWT's and released into the Columbia River at the Beacon Rock boat ramp.

Post seining began on June 1. A total of 6,899 juvenile chinook were examined during post seining for the presence of CWT's from Ives Island to Skamania Island. The percent of adipose clipped fish collected in the index areas ranged from 0% to 13%. Sixteen adipose clipped fish ranging in size from 57-95mm were sacrificed in order to collect and decode CWT's. The first CWT fish was sacrificed June 3 and the last fish was sacrificed on June 28.

After the CWT's were decoded, reading indicates 8 were from the BTD project. Five were 2004 brood upriver brights from Tanner Creek hatchery, 2 were 2004 brood Klickitat hatchery, and one was from CRIFC. From June 3 through June 17 (5 sampling days), only tags from the BTD project were recovered. From June 21 through June 28 (3 sampling days) only tags from other projects were recovered.

Based on general observations, timing, and recovery of CWT's it appears that juveniles that originate from the spawning population below Bonneville Dam are the majority of the population of zero age chinook in mid June. Using the juvenile CWT recovery data it appears

that the juveniles originating from the local spawning population are present below Bonneville Dam into mid June. It also appears that juveniles from other releases are not present until late June, and the below Bonneville juveniles have migrated out of the area.

References

Duff, Cameron. Oregon Department of Fish and Wildlife. Personal communication with the author.

Hillson, Todd. Washington Department of Fish and Wildlife. Personal communication with the author.

Marshall, Anne. 1998. Washington Department of Fish and Wildlife. Genetic Analysis of Mainstem Columbia River, Below Bonneville Dam, Chinook Spawners. Memo to Kelly Harlan, 9 Feb. 1998.