BONNEVILLE POWER ADMINISTRATION

2004 Evaluation of Chum, Chinook and Coho Salmon Entrapment near Ives Island in the Columbia River

Annual Report 2004 August 2005 DOE/BP-00004287-3

This Document should be cited as follows:

Duston, Reed, Jeremy Wilson, "2004 Evaluation of Chum, Chinook and Coho Salmon Entrapment near Ives Island in the Columbia River", 2004 Annual Report, Project No. 199900301, 70 electronic pages, (BPA Report DOE/BP-00004287-3)

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.

2004 EVALUATION OF CHUM, CHINOOK, AND COHO SALMON ENTRAPMENT NEAR IVES ISLAND IN THE COLUMBIA RIVER

Prepared by

Reed A. Duston

And

Jeremy Wilson

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 528.04

ACKNOWLEDGEMENTS

EDITORIAL ASSISTANCE

Chris Murray	Pacific Northwest National Laboratory

ADDITIONAL FIELD SAMPLING

Rick Heitz	Pacific States Marine Fisheries Commission
Cameron Duff	O.D.F.W.
Robert Brooks	O.D.F.W.

CONTENTS

Tables

(Additional tables are in Appendix B)

Tables continued…

FIGURES

Figures continued…

Photographs

Appendix A: Site Coordinates

Appendix B: Tables

Tables continued…

From January to July of 2004, 33 entrapments and 56 stranding sites were examined on the Columbia River near Ives Island, downstream of Bonneville Dam. A total of 7,834 salmonids, made up of three species, were collected (Table 1). The fish sampled during this time were chinook salmon (85%), chum salmon (8%), and coho salmon (7%). The following analysis of the relationship between environmental factors and salmon placed at risk by river level fluctuations focuses on each of these three species of salmon.

Table 1. Total number of fish observed during the late winter through early summer sampling period (January 22 – June 20) near Ives Island in 2004.

Common Name	Scientific Name	Entrapped		Stranded		
		Mortality	Live	Mortality	Live	Total
Chinook Salmon	Oncorhynchus tshawytscha	28	6193	416	15	**6652**
Chum Salmon	Oncorhynchus keta	1	498	130	4	**633**
Coho Salmon	Oncorhynchus kisutch	2	455	92	0	**549**
Total		**31**	**7146**	**638**	**19**	**7834**

Methods and Definitions

An attempt was made to survey the entire Ives Island study area every one to three days. This of course does not mean that all stranded and entrapped salmon were sampled. Staff scheduling, timing of low water, predators and scavengers are just some of the factors making complete sampling all but impossible.

All numbers within this report are actual observations; there has been no attempt to estimate the number of entrapped or stranded fish that went unsampled. *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 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.

Each entrapment was measured for size, depth, distance to the river, height above river, and temperature. Visual estimates of dominant substrate size and vegetation densities were also recorded.

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.

2. Seasonal Trends

Sampling began on January 22, 2004, and ended on June 20, 2004. The first and last sampling dates on which threatened chum salmon were observed were February 15, 2004, and May 26, 2004, respectively. The weekly sampling results of chum salmon are listed in Table B1 (Appndx. B) and plotted in Figure 1. Peak numbers of threatened chum were observed throughout March and during a 7-day period in mid-April. There were 131 mortalities, approximately 20.7 % of the total number of observed threatened chum salmon.

The first and last sampling dates on which chinook salmon were observed were February 3, 2004 and June 20, 2004, respectively. The weekly sampling results of chinook salmon are listed in Table B2 and plotted in Figure 2. Peak numbers of chinook salmon were observed mid February through late May. There were 444 mortalities, approximately 6.8% of the total number of observed chinook salmon.

The first and last sampling dates on which coho salmon were observed were February 3, 2004, and May 26, 2004, respectively. The weekly sampling results of coho salmon are listed in Table B3 and plotted in Figure 3. Peak numbers of coho salmon were observed throughout March. There were 93 mortalities, approximately 16.9% of the total number of observed coho salmon.

Figure 1. Weekly sampling results of threatened chum salmon. No chum were sampled during the week ending 5/22. One chum was sampled in each of the weeks ending 5/8, 5/15, and 5/29. Two chum were sampled during the week ending 2/28.

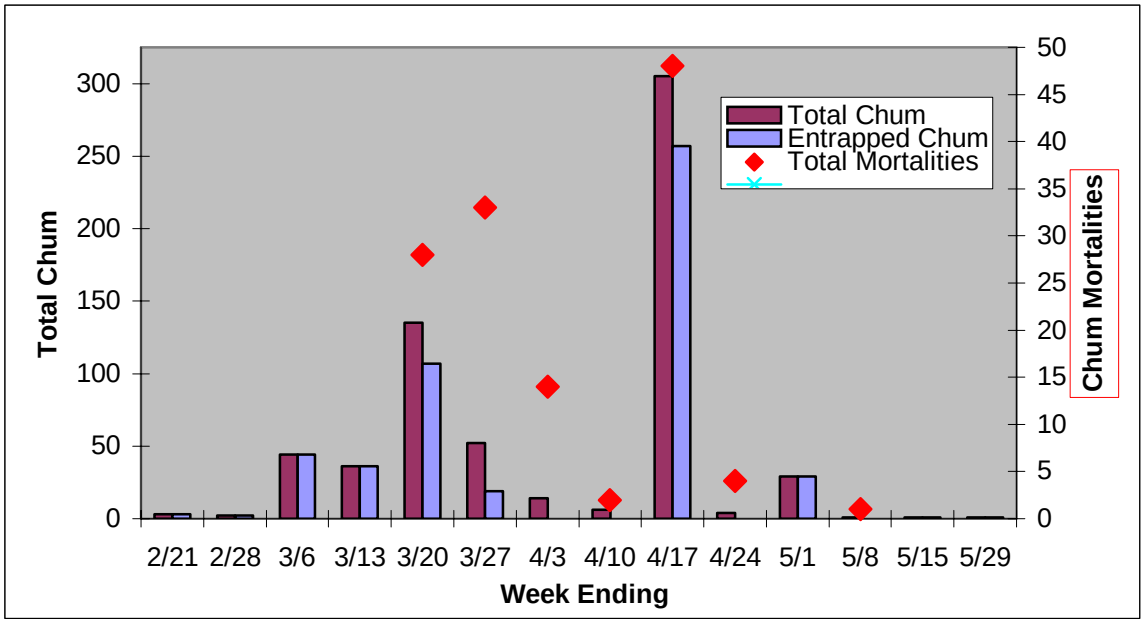


Figure 2. Weekly sampling results of chinook salmon. Between two and four chinook salmon were sampled during each of the weeks ending 2/14, 2/28, 5/8, and 6/12. No chinook were sampled during the weeks ending 6/5 and 6/19

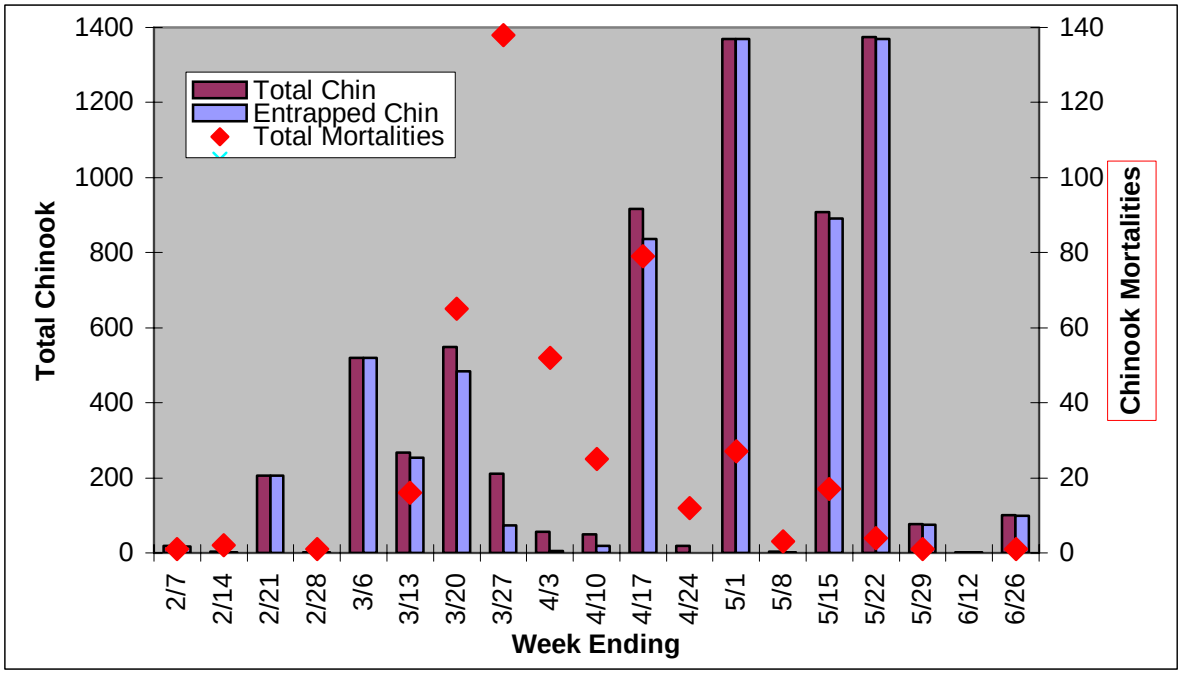
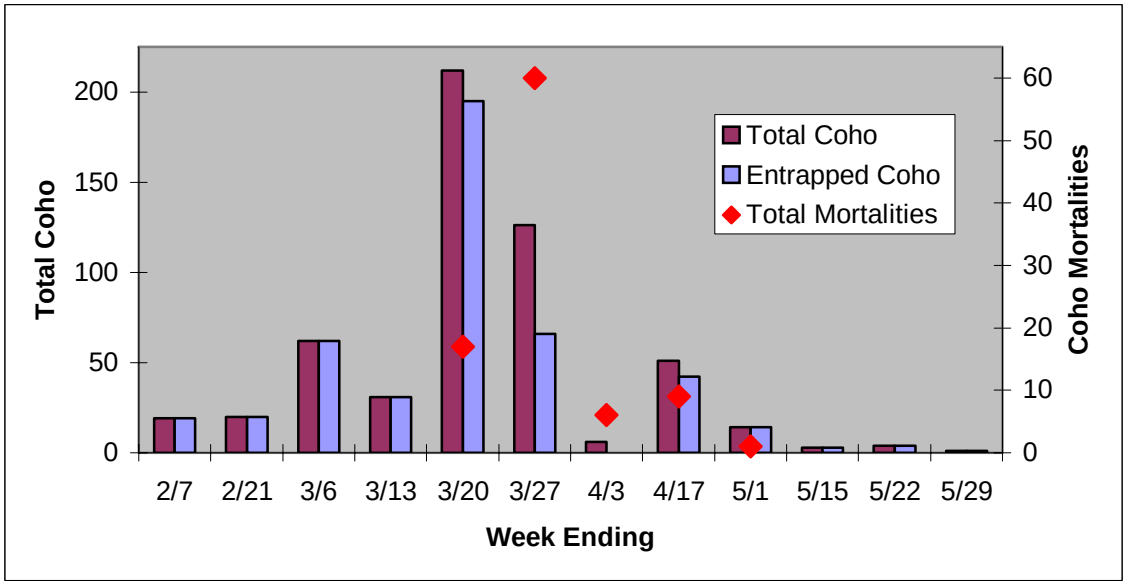


Figure 3. Weekly sampling results of coho salmon One live entrapped coho was sampled during the week ending 5/29. No coho were sampled during the weeks ending 2/14, 2/28, 4/10, 4/24, and 5/8.



3. Distribution

Although an attempt was made to survey the entire study area every one to three days, 97.3% of the salmon sampled during 2004 were found within three major sampling areas, designated A, C, and E (Photo.1, Table 2). These sampling areas were first identified during previous years and, along with area D, have consistently been responsible for the vast majority of stranded and entrapped salmonids in the study area. Several entrapments were sampled repeatedly as fluctuating water levels continued to replenish and then isolate their contents. Subsequent samples are identified in the tables as –2 (2nd sampling), -3 (3rd sampling), etc. Based on cumulative totals, 68.6% of all sampled fish were found within four entrapments (Photo 2, Table 3). A brief description of each of the four major entrapments along with a description of entrapments with high mortality follows Photo 2.

Entrapped chinook salmon comprised the largest numbers in Areas A, B, C, and E. Coho salmon comprised the largest numbers in Area F (Table 2, Figure 4).

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.

Photograph 1: Sampling Areas: A through F

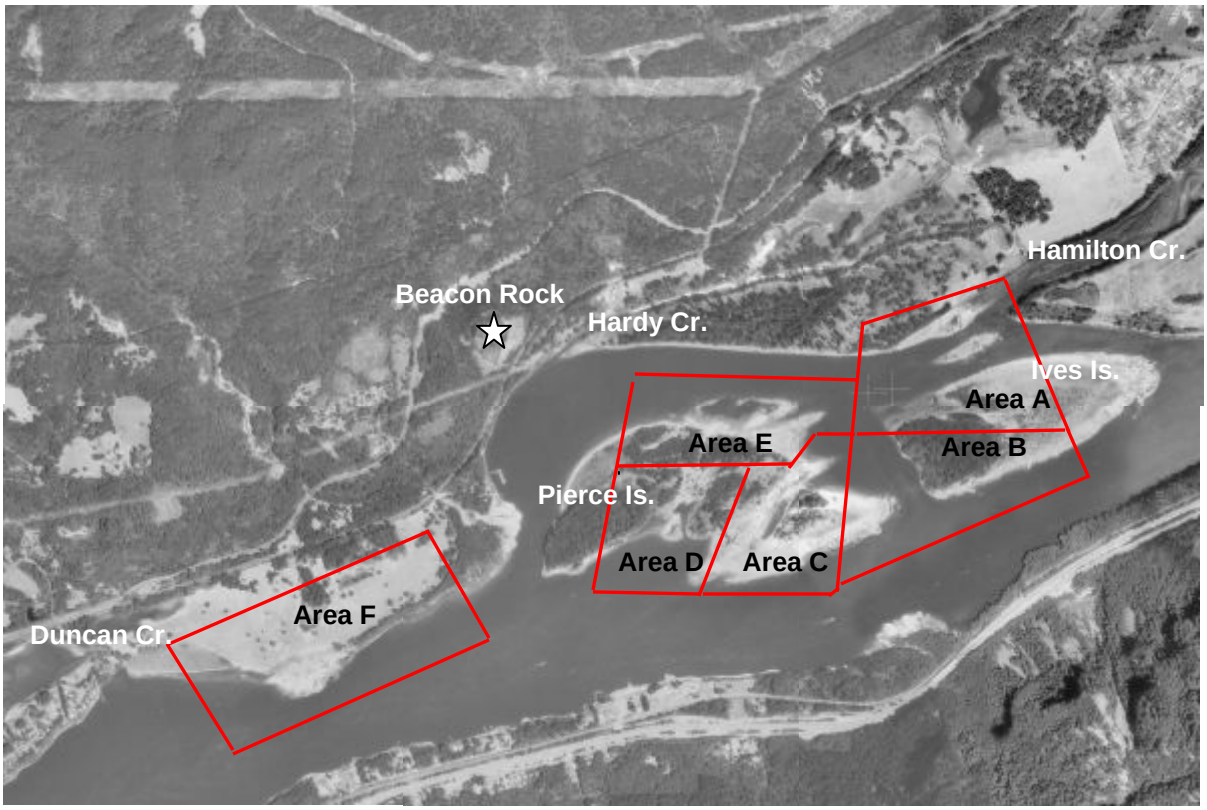


Table 2. Spatial distribution of chinook, coho, and threatened chum salmon

	Sampling Area						
	A	**B**	**C**	**D**	**E**	**F**	**Undesignated**
River Mile (statute miles)	142.35 to 142.75	142.15 to 142.5	141.9 to 142.25	141.8 to 142	141.8 to 142.2	140.7 to 141.7	
Entrapped Chum	169	0	2	0	316 (1)	12	0
Stranded Chum	29 (25)	0	0	0	105 (105)	0	0
Total Chum	198 (25)	0	2	0	421 (106)	12	0
% of all Chum sampled	31.28%	0.00%	0.32%	0.00%	66.50%	1.90%	0.00%
Entrapped Chinook	1701 (1)	19	2727	2	1740 (27)	32	0
Stranded Chinook	112 (97)	3	9	0	303 (303)	0	4
Total Chinook	1813 (98)	22	2736	2	2043 (330)	32	4
% of all Chin. Sampled	27.25%	0.33%	41.13%	0.03%	30.71%	0.48%	0.06%
Entrapped Coho	180	0	23	2	116 (1)	136	0
Stranded Coho	1 (1)	0	0	0	90 (90)	0	1
Total Coho	181 (1)	0	23	2	206 (91)	136	1
% of all Coho Sampled	32.97%	0.00%	4.19%	0.36%	37.52%	24.77%	0.18%
Total Salmon	2192 (124)	22	2761	4	2670 (527)	180	5
% of all Salmon Sampled	27.98%	0.28%	35.24%	0.05%	34.08%	2.30%	0.06%

Figure 4. Spatial distribution of chum, chinook, and coho salmon Two chum were sampled in Area C. Two chinook and two coho were sampled in Area D. Four chinook and one coho were sampled outside of designated areas.

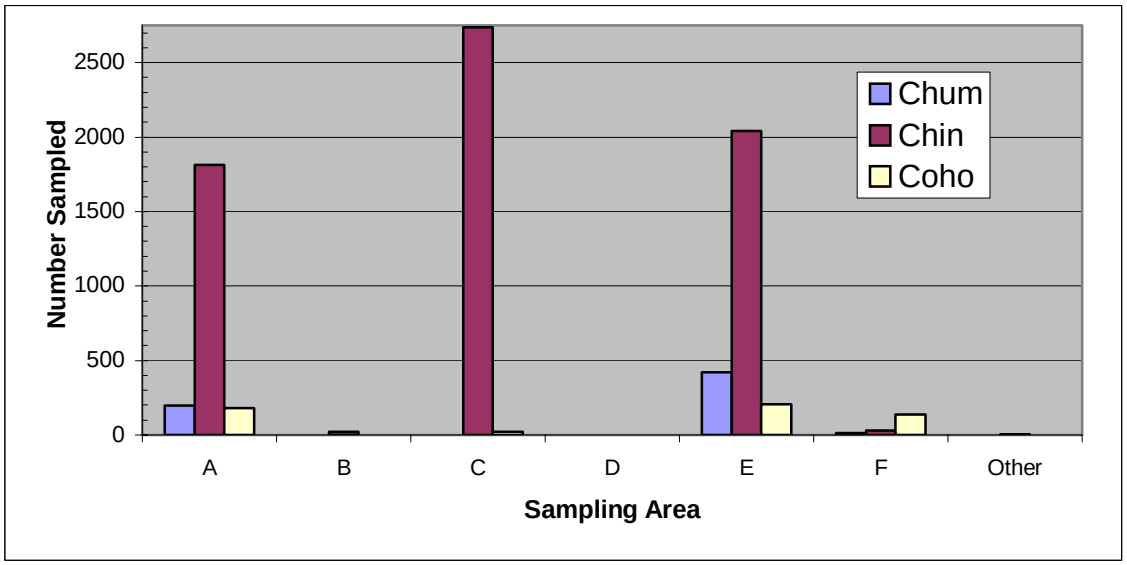
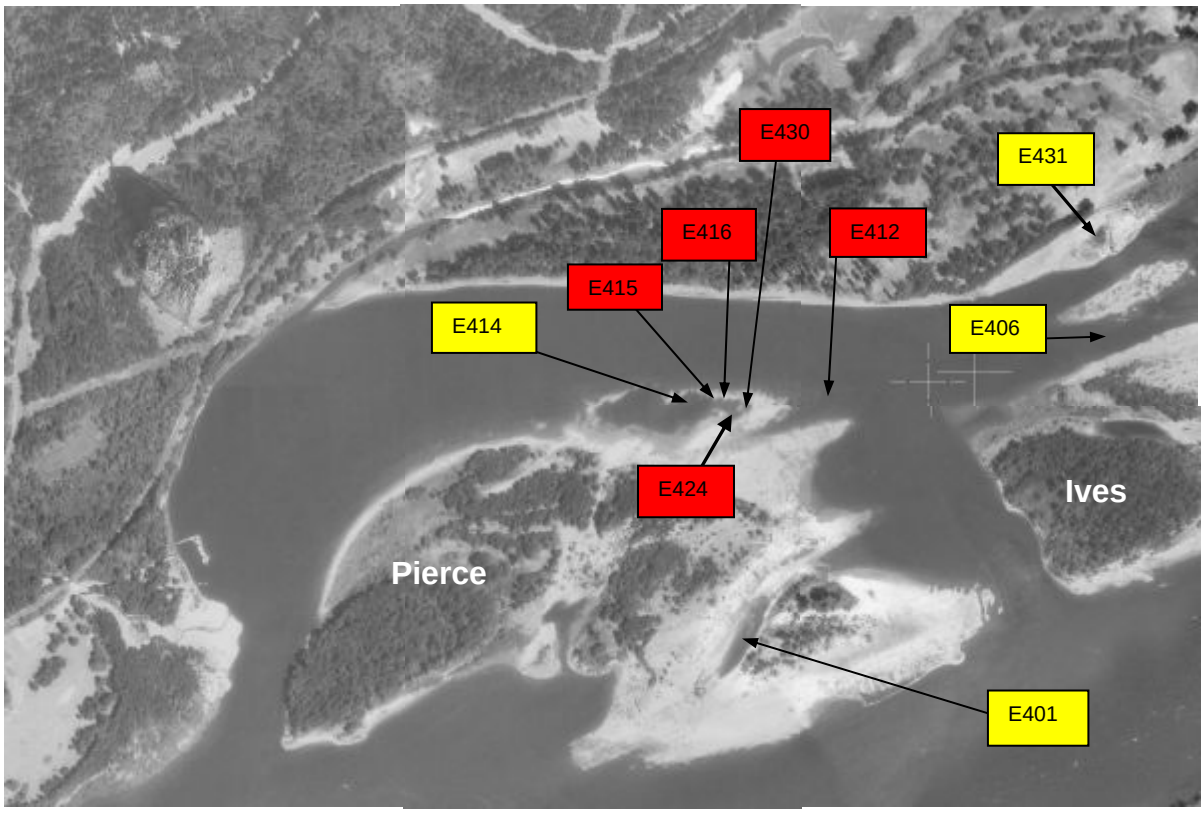


Table 3. Accumulated salmon counts and spatial distribution for entrapment sites containing the majority of sampled fish (includes fish found at stranding sites located within the perimeters of a dewatered entrapment). Numbers in parenthesis represent mortalities.

	Entrapment					
	E401	**E406**	**E414**	**E431**	**E415**	**E416**
Chum salmon	2	158	133	2	28 (16)	68 (58)
Chinook salmon	2727	1195	408	457	306 (97)	345 (136)
Coho salmon	23	170	94	8	16 (14)	59 (51)
Total salmon	2752	1523	635	467	350 (118)	472 (245)
% of all sampled salmon	35.13%	19.44%	8.11%	5.96%	4.47%	6.02%
% of all sampled mortalities	0.00%	0.00%	0.00%	0.00%	17.00%	36.70%
River Mile	142.11	142.61	142.1	142.75	142.1	142.1
Latitude	N45.62028	N45.62577	N45.43666	N45.62751	N45.62454	N45.62459
Longitude	W122.00493	W121.99504	W122.00755	W121.99550	W122.00545	W122.00513
Sampling Area	**Area C**	**Area A**	**Area E**	**Area A**	**Area E**	**Area E**

Photograph 2: Notable entrapments of 2004, sites in red had high mortality (U.S.G.S. photograph taken 8/3/2000)



The following are brief descriptions of noteworthy entrapments in 2004.

E401 (35.13% 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.

E406 (19.44% of all sampled salmon) 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. When at its' largest stage, E406 had a surface area of approximately .6 acre. Water flowing into the area comes from Hamilton Channel. The surface waters of Hamilton Channel were, at times, higher than E406 but blocked by a broad low-lying berm. In some cases, subsurface flow, probably coming from Hamilton Channel, replenished water within E406 without allowing entrapped salmon an opportunity to escape.

E414 (8.11% of all sampled salmon) is a broad shallow pond forming west of E415 and E416 along the north central shore of Pierce Island. When at its' largest stage, E414 had a surface area of approximately .9 acre. Water backs into it via a larger and deeper pond to the west and, when high enough, flows into it from the channel separating Ives and Pierce Islands to the east. E414 is within a large area of undulating topography, which includes many other lesser entrapments.

E415 (4.47% of all sampled salmon, 17.66% of all known mortalities) is within a cluster of entrapments along the north central shore of Pierce Island. E415 became increasingly noteworthy in 2004 because of the large number of salmon mortalities discovered within its' perimeter.

E416 (6.02% of all sampled salmon, 36.68% of all known salmon mortalities) is within the same cluster of entrapments as E415. E416 became increasingly noteworthy in 2004 because of the large number of salmon mortalities sampled within its' perimeter.

E412, E424, and E430. When combined with E415 and E416, these sites encompassed an area containing 75% of known chum mortalities, 68% of the known chinook mortalities and 97% of the known coho mortalities. This is also an area of documented thermal poisoning, which, if not for sampler intervention, would have caused the death of an additional 558 juvenile salmon, 26 of which would have been chum.

4. Tailwater Levels

Bonneville tailwater data was retrieved from the NWP Water Management: Data Query web site (http://www.nwd-wc.usace.army.mil//cgi-bin/DataQuery).

Six hundred twenty four (98.5%) of the sampled chum were found during March and April when Bonneville tailwater levels ranged between 11.8 and 19 feet. One hundred thirty (99.2%) of the known chum mortalities were discovered between 3/14 and 4/17 when Bonneville tailwater levels ranged from 11.9 to 18.2 feet with weekly medians ranging from 13.4 to 14.8 feet (Figures 5 & 6).

Six thousand three hundred nine (94.7%) of the sampled chinook were found during March, April and May when Bonneville tailwater levels ranged between 11.8 and 23.2 feet. Four hundred fourteen (93.2%) of the known chinook mortalities were discovered between 3/7 and 5/1 when Bonneville tailwater levels ranged from 11.8 to 19 feet with weekly medians ranging from 12.4 to 15.1 feet**.**

Four hundred eighty (87.4%) of the sampled coho were found during March and April when Bonneville tailwater levels ranged between 11.8 and 19 feet. Ninety-three of the 94 known coho mortalities were discovered between 3/14 and 4/17 when Bonneville tailwater levels ranged from 11.9 to 18.2 feet with weekly medians ranging from 13.4 to 14.8 feet.

Chum and coho salmon may have been stranded within the given tailwater ranges simply because it was the only time they were present in any significant number, both their entrapment and stranding numbers decline at about the same time.

Unlike chum and coho, the period of greatest chinook stranding differed from the period of greatest chinook entrapment. One reason may be because the lower fluctuating river levels of March and April expose larger expanses of shallow depressions conducive to first entrapping and then stranding juvenile salmon. A second reason may be that juvenile chinook were larger in May and June and were therefore less likely to become entrapped in the shallow pools that eventually became dewatered.

Figure 5: Weekly tailwater measurements associated with entrapped juvenile salmon

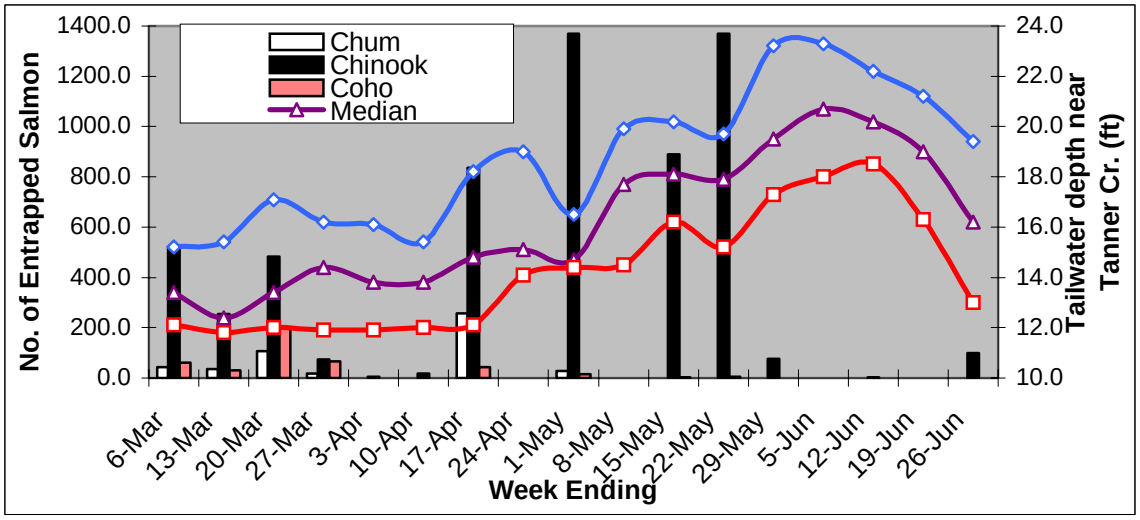
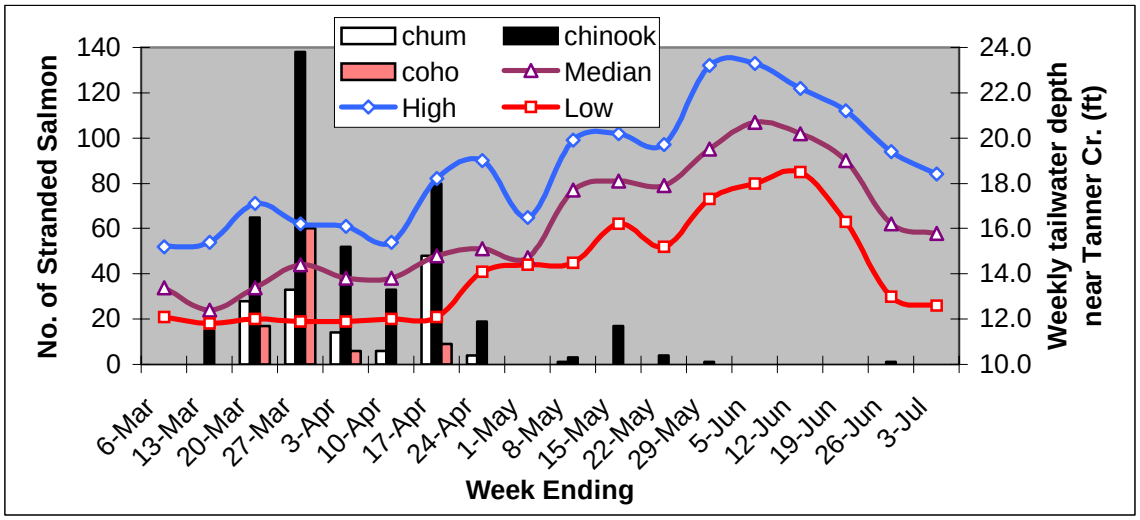


Figure 6: Weekly tailwater measurements associated with stranded juvenile salmon



At various times, each entrapment's height above the river was measured. 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. Theoretically, the height above the river could be used in conjunction with Bonneville tailwater measurements to determine the each entrapments critical tailwater level (the level at which an entrapment forms). The unknown effects of river attenuation, channel hydrology within the study area as well as varying river velocities prevented us from identifying specific critical tailwater levels, however, repeated measurements, especially when the river was close to reconnecting with an entrapment, make it reasonable to identify some tailwater ranges within which certain entrapments probably formed. The tailwater ranges within which the entrapments containing 69% of the salmon sampled in 2004 as well as the numbers of salmon found in those entrapments are listed in Table 4.

At least forty-six percent of all chum sampled during 2004 were retrieved from entrapments that were likely to have formed when Bonneville Dam tailwater levels dropped to points between 11.5 and 12.9 feet. A minimum of 24.1% of all sampled chinook and 48.1% of all sampled coho were retrieved from the same entrapments. An additional 41+% of sampled chinooks were retrieved from entrapments that were likely to have formed when tailwater levels dropped to points between 15.9 and 17.5 feet.

Table 4: Tailwater levels associated with the formation of four entrapments containing 69% of the juvenile salmon sampled in 2004

ENTRAPMENT CODE SAMPLED SALMON (2004)	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)
E406 (Ives Is.) 158 CHUM, 1195 CHIN, 170 COHO	02/15/04	1400	0.42	12.3	12.2-12	**11.5 to 12.5**
	03/01/04	1200	0.44	13.5	13.3-12.2	
	03/09/04	1000	0.123	12.4	12.3-12.1	
E414 (Pierce Is.) 133 CHUM, 408 CHIN, 94 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	
E401 (Pierce Is.) 2 CHUM, 2727 CHIN, 23 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	
E431 (Pierce Ranch NWR) 2 CHUM, 457 CHIN, 8 COHO	05/08/05	1000	-0.08	18.8	17.6-18.7	**18.5 to 19.5**
	05/10/04	1000	1.3	16.6	16.8-16.6	
	04/23/03	900	0.02	18.8	18.2-17.2	

During 2004, ninety-seven percent of the known chum mortalities and ninety-eight percent 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 caused over 99% of the chum mortalities and 96% of the total salmon mortality.

For every dewatered entrapment there are two tailwater levels critical to salmon. One is the point at which the entrapment is formed and the other is the point at which the entrapment becomes dewatered. Some entrapment/stranding sites were surveyed both with and without water. Many entrapment/stranding sites were sampled only when dry.

Eighty-nine (66%) of the known chum mortalities, 272 (59%) of the known chinook mortalities, and 87 (93%) of the known coho mortalities were found within a cluster of entrapments along the north shore of Pierce Island. Without sampler intervention, an additional 14 chum, 226 chinook, and 3 coho would have undoubtedly died (most from thermal poisoning) at the same sites.

Entrapment sites immediately east of the cluster contained an additional 14 chum mortalities, 39 chinook mortalities, and 4 coho mortalities. Two more chum and 111 more chinook would have died at these other sites if not for sampler intervention.

When combined, the above sites, all within a relatively small area, contained 75% of the known chum mortalities, 68% of the known chinook mortalities, and 97% of the known coho mortalities. Nearly all of the salmon mortalities found at these sites became entrapped when tailwater depths dropped to levels between 14.0 and 15.2 feet (Table 5).

Table 5: Tailwater levels associated with the formation of entrapments with high mortality

ENTRAPMENT CODE SALMON MORTS (2004)	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)
E416 (Pierce Is.) 58 chum, 136 chin, 51 coho	05/01/05	1400	even	14.6	14.5-14.4	**14.1-15.1**
	04/06/05	900	even	15.3	14.4-13.7	
E424 (Pierce Is.) 14 chum, 34 chin, 18 coho	05/01/05	1400	even	14.6	14.5-14.4	**14.1-15.1**
	04/26/04	1300	0.375	14.6	14.6-14.6	
E415 (Pierce Is.) 16 chum, 97 chin, 14 coho	05/01/05	1400	-0.25	14.6	14.5-14.4	**14.0-15.0**
	04/06/05	900	-0.25	15.3	14.4-13.7	
E412 (Pierce Is.) 9 chin	04/26/04	1500	0.21	14.5	14.6-14.6	**14.0-15.0**
E430 (Pierce Is.) 1 chum, 5 chin, 4 coho	05/02/04	1000	even	14.7	14.7-14.8	**14.2-15.2**

Identifying which tailwater level causes the dewatering of an entrapment is much more difficult than identifying the level that creates an entrapment. To determine when an entrapment becomes dewatered one must know the river levels required to drop the water table below the lowest point in the entrapment and the length of time required for the water in the entrapment to percolate through the substrate. Data identifying specific dewatering conditions has not been collected however it should be assumed that any entrapment with a history of dewatering places juvenile salmon in extreme jeopardy.

High ramping rates are probably more significant in the formation of entrapments likely to become dewatered than they are in the formation of other entrapments. Entrapments most likely to become dewatered tend to be small and shallow when formed, if given the time, salmon are more likely to leave those sites prior to becoming entrapped. Ramping rate loses significance once an entrapment has formed since, without the opportunity of escape, entrapped salmon are certain to die regardless of how long it takes the entrapment to become dewatered.

The average (mean) degree of fluctuation (the difference between the highest and lowest level) and the average 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 1.9 to 4.0 feet with a mean fluctuation of 2.7 feet (Figure 7). The degree of continuous tailwater decline during the same periods ranged from 0.3 to 4.0 feet with a mean continuous decline of 2.6feet. (Table B4, Figure 8)

The degree of fluctuation in Bonneville tailwater levels during the 24-hour periods preceding the discovery of chinook salmon mortalities ranged from 0.6 to 4.0 feet with a mean fluctuation of 2.4 feet. 98.6% of chinook mortalities were preceded by fluctuations of 1.5 to 4.0 feet. (Figure 7) The degree of continuous tailwater decline during the same periods ranged from 0.3 to 4.0 feet with a mean continuous decline of 2.4feet. (Table B4, Figure 8)

The degree of fluctuation in Bonneville tailwater levels during the 24-hour periods preceding the discovery of coho salmon mortalities ranged from 2.0 to 3.5 feet with a mean fluctuation of 2.6 feet. (Figure7) The degree of continuous tailwater decline during the same periods ranged from 0.5 to 3.5 feet with a mean continuous decline of 2.5 feet. (Table B4, Figure 8)

Figure 7: Maximum tailwater fluctuation during the 24 hr. periods immediately preceding known salmon mortality

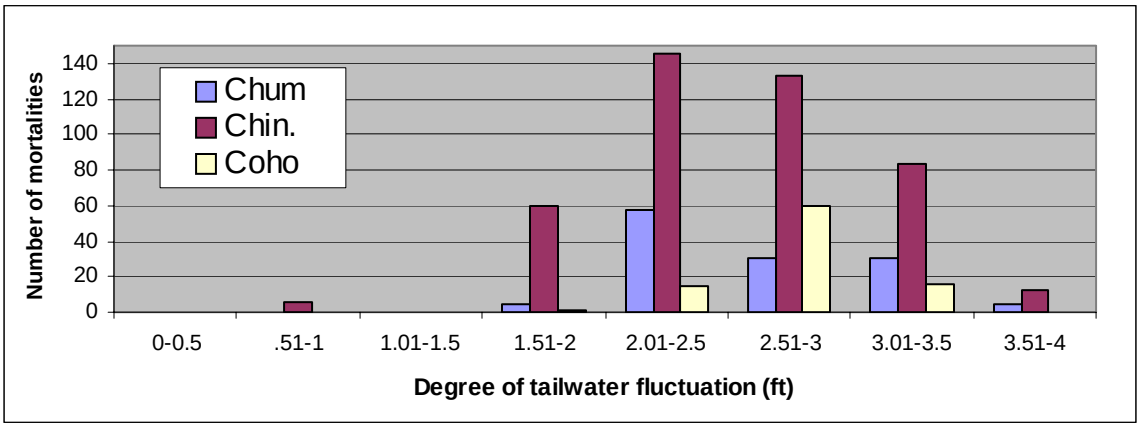
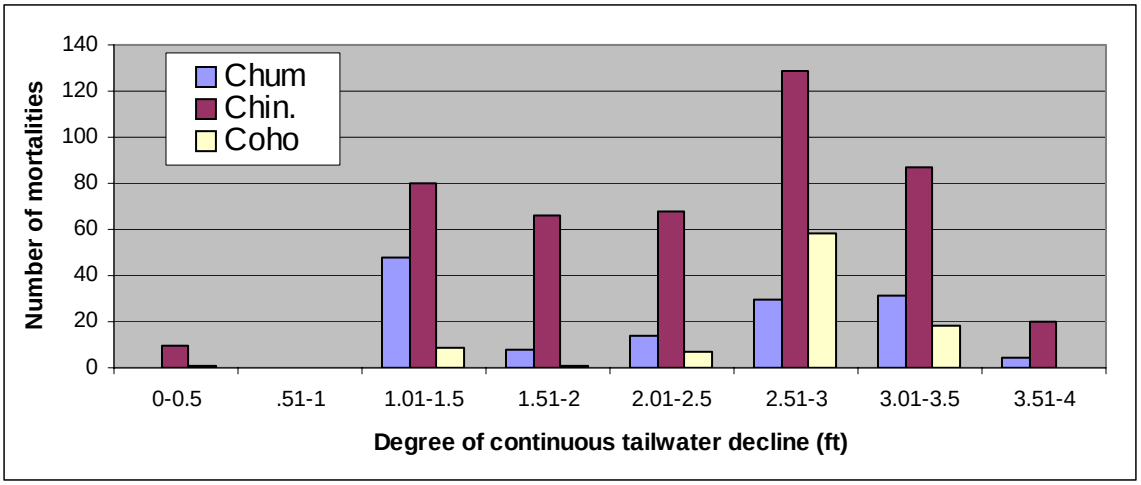


Figure 8: Degree of maximum continuous tailwater decline during the 24 hr. periods immediately preceding known salmon mortality



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. Nearly 96% of all known chum mortalities and similar percentages of chinook and coho mortalities (84.3% and 98.9%, respectively) were preceded by continuous tailwater declines that began at levels

no higher than 15.7 feet and ended at levels no lower than 11.9 feet. When taken as a whole, 88.5% of all known salmon mortalities were preceded by continuous tailwater declines beginning at levels no higher than 15.7 feet and ending at levels no lower than 11.9 feet (Table B4).

5. Size Susceptibility

Mean, maximum, and minimum fork lengths for 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 9, along with the median fork length (horizontal bars). The weekly median fork length for entrapped chum salmon ranged from 38 to 45 mm prior to May 1 and from 42 to 72 mm after May 1. The mean fork length for chum entrapped prior to May 1 was 44.7mm and 51.3mm after May 1.

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 10, along with the median fork length. The median fork length for entrapped chinook salmon ranged from 36-50mm prior to June 16th. Ninety-nine chinook salmon were sampled after June 16th with a median fork length of 64mm. The mean fork length for entrapped chinook was 44.4mm prior to May, 45.7mm during May, and 64.2mm 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 11, along with the median fork length. During the week ending February 7, nineteen entrapped coho were sampled with a median fork length of 108mm. Between February 7 and May 8 the weekly median fork length ranged from 38-42mm then increased to 46-57mm through May 29. With the exception of the coho entrapped during the week ending February 7, the mean fork length of entrapped coho was 39.1mm prior to May 1 and 53.3mm after May 1.

Figure 9. Minimum, maximum and median fork length of threatened chum salmon collected at entrapment sites near the Ives Island of the Columbia River in 2004. 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.

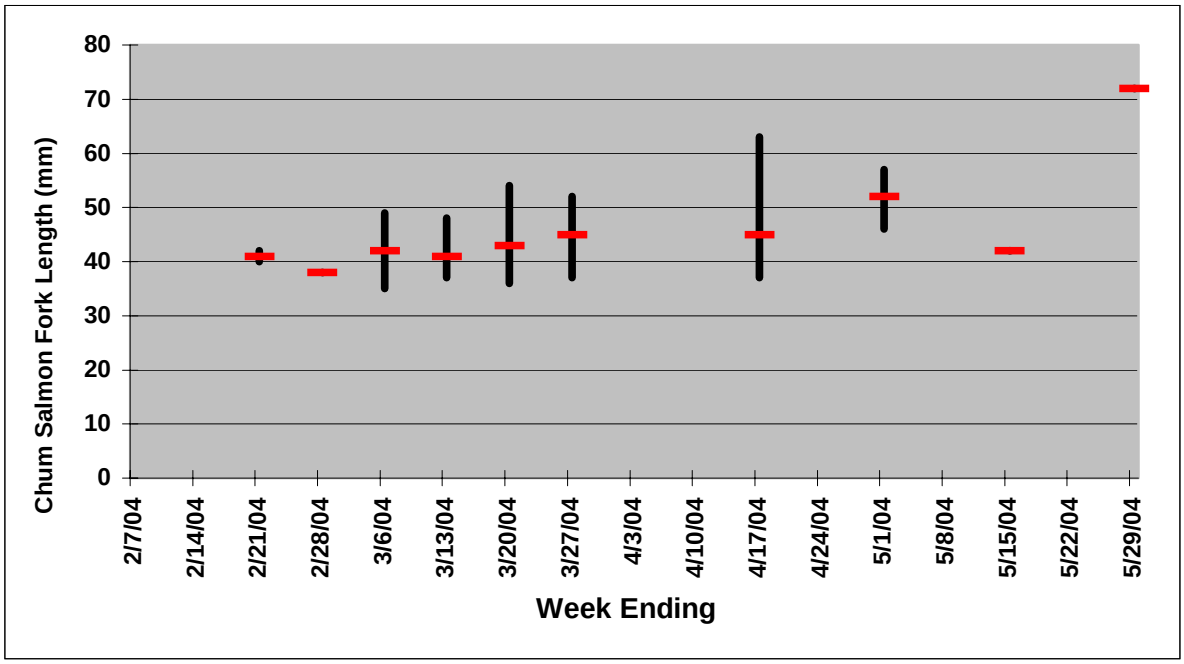


Figure 10. Minimum, maximum and median fork length of chinook salmon collected at entrapment sites near Ives Island of the Columbia River in 2004. The lower and higher ends of the lines represent the minimum and maximum fork length observed in the sample for the week, with the horizontal dashes as the median fork lengths.

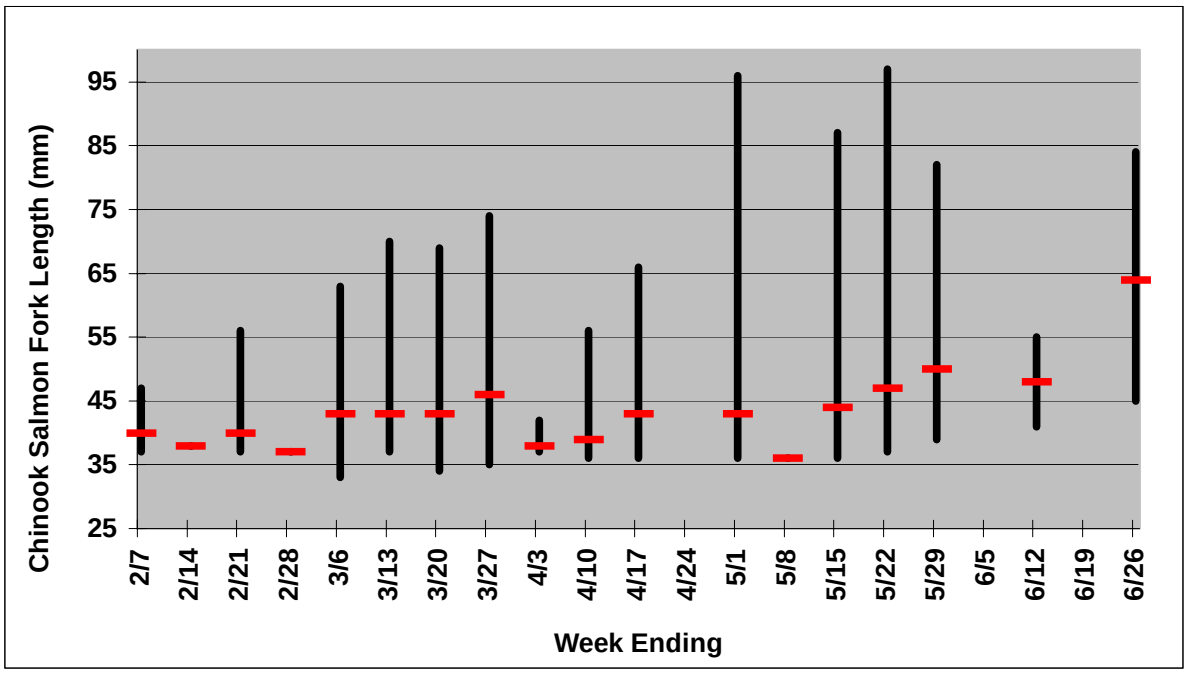
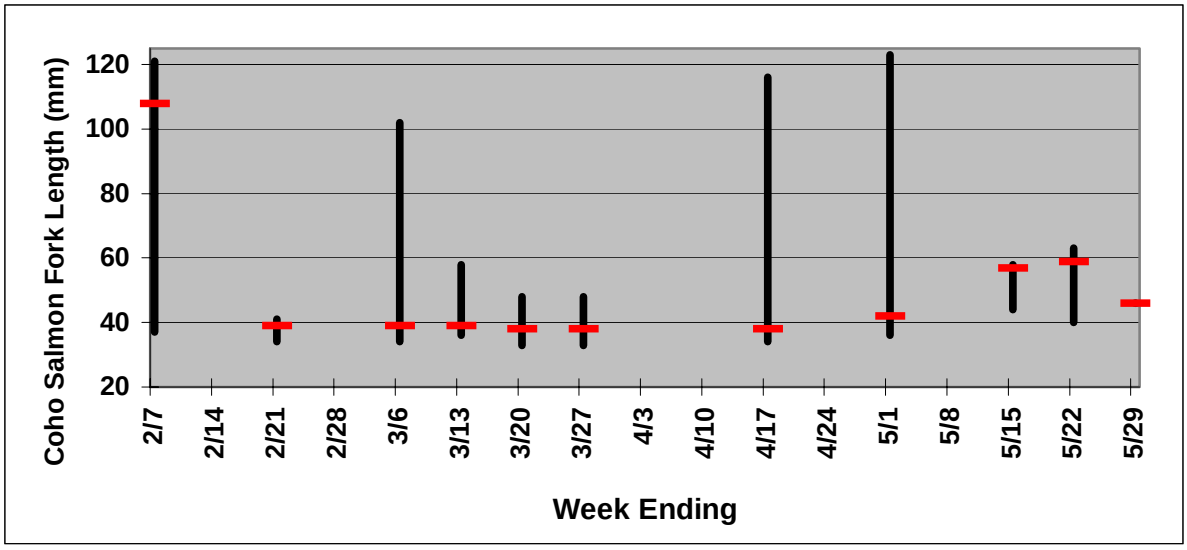


Figure 11. Minimum, maximum and median fork length of coho salmon collected at entrapment sites near the Ives Island of the Columbia River in 2004. The lower and higher ends of the lines represent the minimum and maximum fork length observed in the sample for the week, with the horizontal dashes as the 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 40.3 mm, 11% shorter than the mean fork length of sampled entrapped chum salmon (45.1mm). The mean fork length of stranded coho salmon was 37.5mm, 11% shorter than the mean fork length of sampled entrapped coho (42.1mm). The mean fork length of stranded chinook salmon was 41.5mm, 9% shorter than the mean fork length of sampled entrapped chinook (45.5mm). 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 40.2mm, 41.3mm, and 37.3mm, respectively, whereas the mean fork lengths for entrapped chum, chinook, and coho were 45.4mm, 47.1mm, and 38.1mm. The differences in mean fork length between entrapped and stranded salmon were significant at the 95% confidence level for chum and Chinook ($p < 0.0005$), but not for coho. Thus, it appears that the fork lengths of entrapped chum and chinook salmon are significantly larger than those of stranded chum and chinook, with mean fork length differences of 5.2 mm for chum and 5.8mm for chinook.

6. 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. The codes of dominant and subdominant substrate at the sampling sites were defined using the following definitions (Nugent, et al., 2000):

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)

Entrapped chum salmon were observed at sites with dominant substrate sizes of fines, coarse gravel, small and large pebble, and cobble (Codes 1, 5, 6, 7 and 8) (Table B11). The percentage of sites with a particular dominant substrate and the percentage of entrapped chum salmon found at sites with that substrate, are plotted in Figure 12. Large pebble (Code 7) appears most often (39.1% of the time) and accounted for 37.7% of all entrapped chum salmon. Sites with dominant substrates made up of fines or coarse gravel (Codes 1 and 5, respectively) contained 60.7% of the entrapped chum.

The single chum entrapment mortality occurred at a site with a dominant substrate of small pebble.

Stranded chum salmon (those found dewatered) were observed at sites with dominant substrates of fines, medium gravel, coarse gravel, small pebble, large pebble, and cobble (Codes 1, 5, 6, 7, and 8). Coarse gravel and large pebble were dominant at sites containing 80.6% of all sampled stranded chum. (Table B12).

Figure 12. Percentage of entrapment sites with a particular dominant substrate, and the percentage of entrapped chum salmon found at those sites.

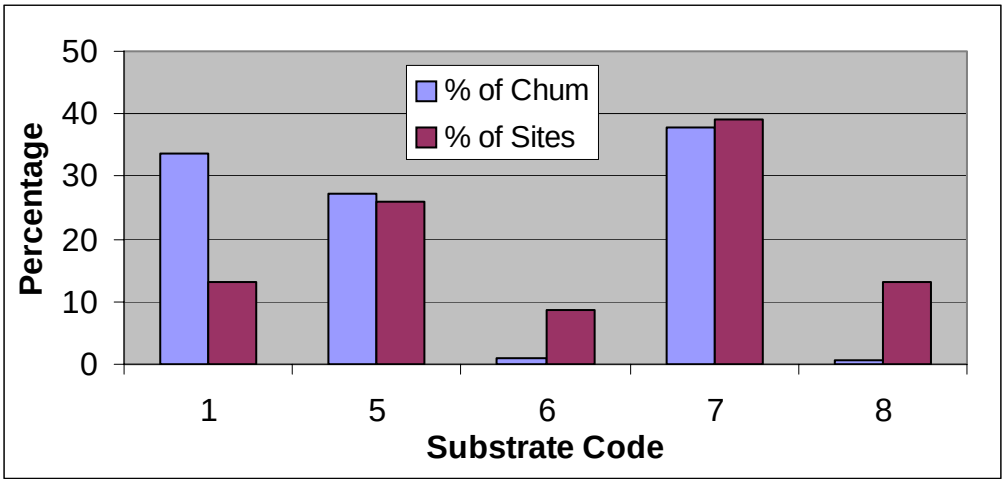
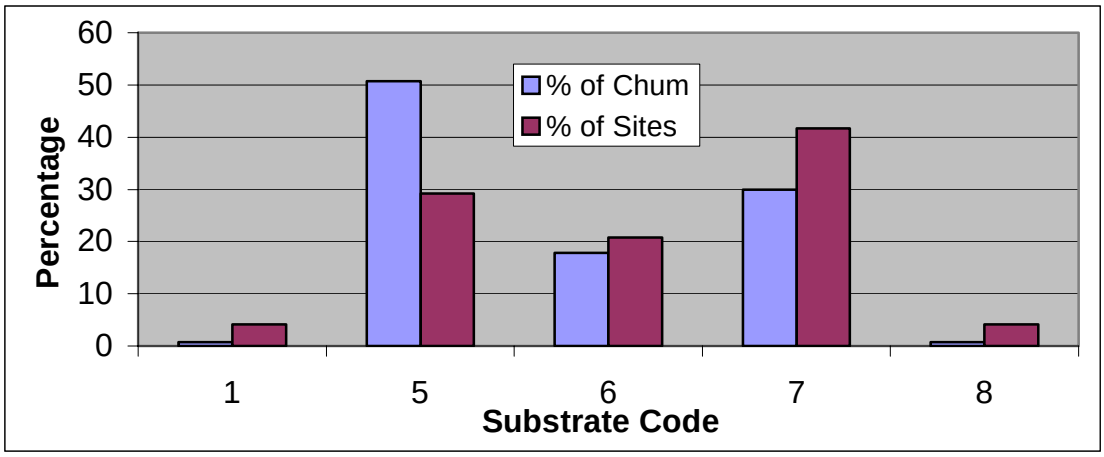


Figure 13. Percentage of stranding sites with a particular dominant substrate, and the percentage of stranded chum salmon found at those sites



Entrapped chinook salmon were observed for dominant substrates the size of fines, coarse gravel, small and large pebble, and cobble (Codes 1, 5, 6, 7, and 8). The dominant substrates coarse gravel (Code 5) and large pebble (Code 7) appear most often accounting for 56.3% of the chinook salmon entrapment sites. The largest numbers of entrapped chinook (51.9%) were also observed at sites with dominant substrates of coarse gravel (Figure 14 and Table B13).

The numbers of mortalities of entrapped chinook salmon were greatest (67.8%) at sites where the substrate small pebble (Code 6) was dominant.

Stranded chinook salmon (those found dewatered) were observed at sites with dominant substrates of fines, fine gravel, medium gravel, coarse gravel, small pebble and large pebble (Codes 1, 4, 5, 6, 7, and 8). Coarse gravel and large pebble were dominant at sites containing 77% of all sampled stranded chinook (Figure 15, Table B14).

Figure 14. Percentage of entrapment sites with a particular dominant substrate, and the percentage of chinook salmon found on those sites.

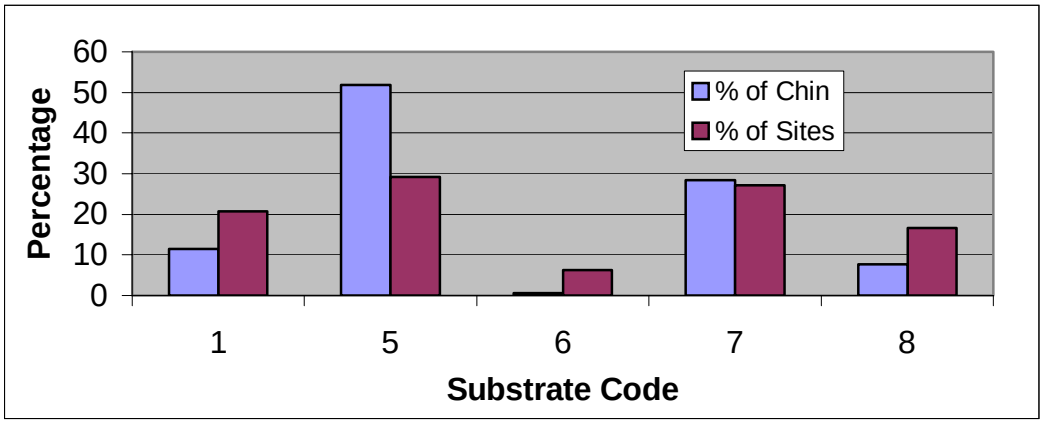
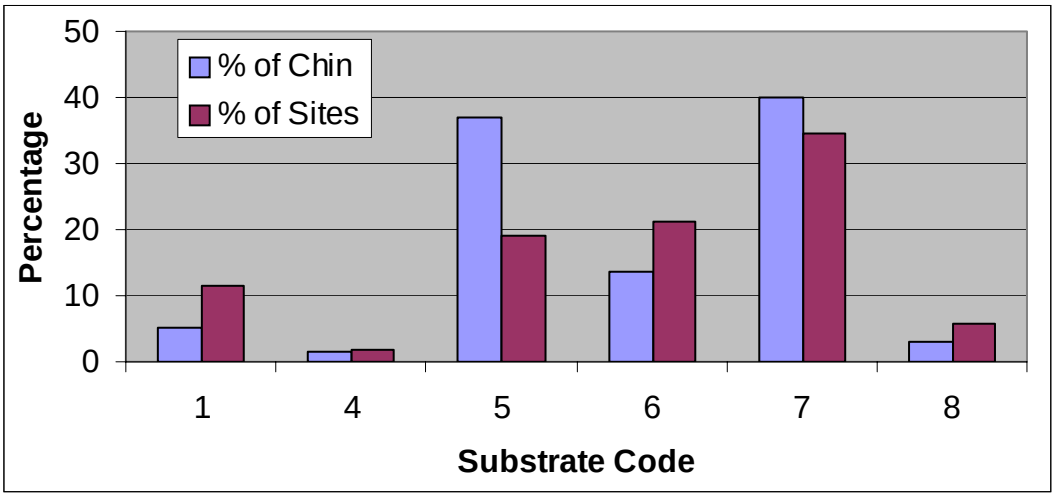


Figure 15. Percentage of stranding sites with a particular dominant substrate, and the percentage of chinook salmon found at those sites.



Entrapped coho salmon were observed for dominant substrate sizes of fines, coarse gravel, small pebble, large pebble, and cobble (Codes 1, 5, 6, 7, and 8). The percentage of sites with a particular dominant substrate and the percentage of entrapped coho salmon found at sites with that substrate, are plotted in Figure 16. The substrates fines, coarse gravel, large pebble, and cobble (Codes 1, 5, 7, and 8) appeared with nearly equal frequency and, when combined, accounted for 96.7% of the sites. Large pebble (Code 7) was the dominant substrate at sites containing the greatest number of coho (39.7%)(Figure 16 and Table B15).

The lone coho entrapment mortality was observed at a site with small pebble (Code 6) as its' dominant substrate.

Stranded coho salmon (those found on dry land) were observed at sites with dominant substrates of fines, coarse gravel, small pebble, and large pebble (Codes 1, 5, 6,and 7). Coarse gravel was the dominant substrate at sites containing 72.8% of all sampled stranded coho (Figure 17, Table B16).

Figure 16. Percentage of entrapment sites with a particular dominant substrate, and the percentage of entrapped coho salmon found at those sites.

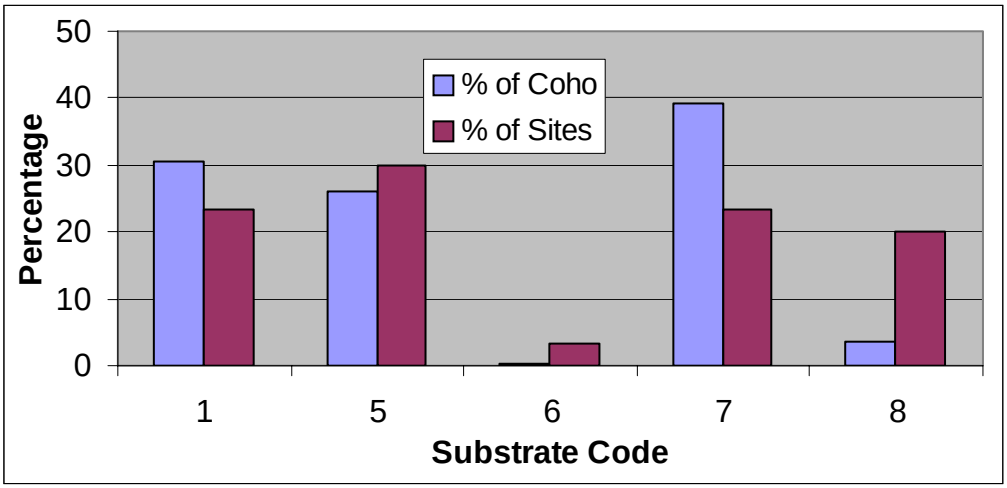
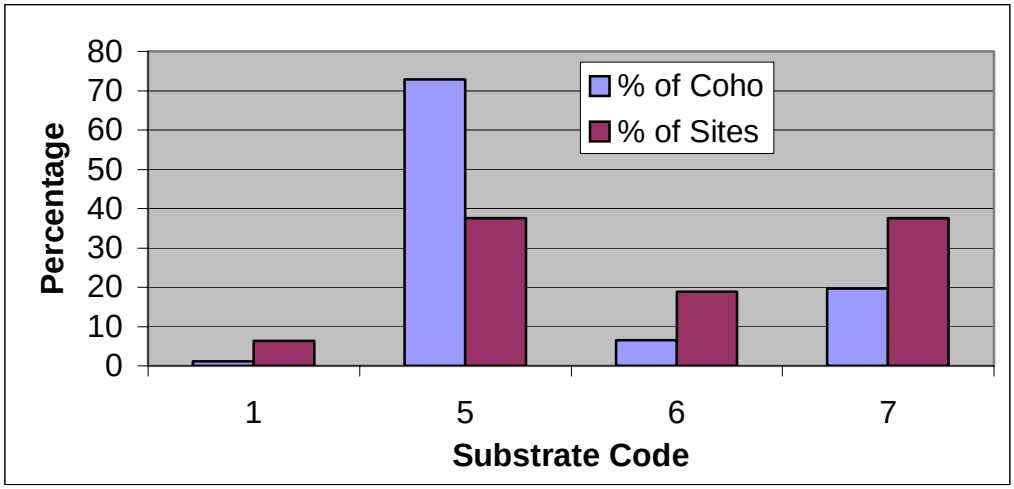


Figure 17. Percentage of stranding sites with a particular dominant substrate, and the percentage of stranded coho salmon found at those sites.



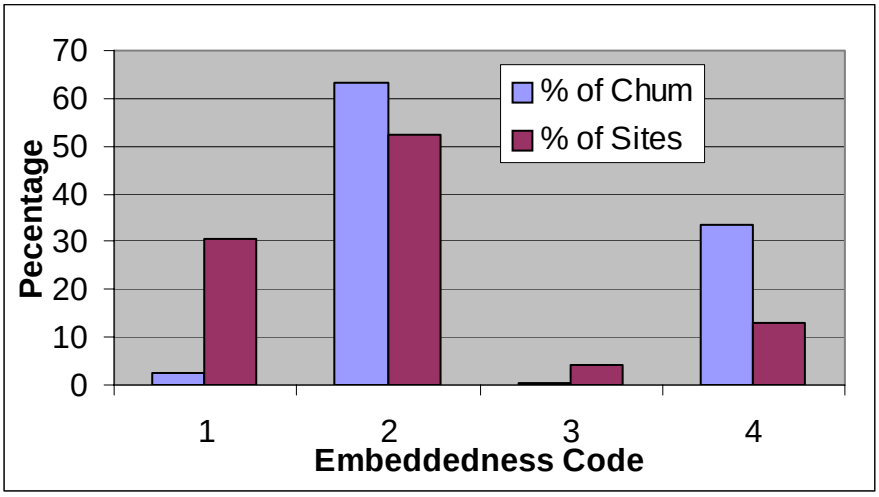
7. Substrate Embeddedness

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 and coded as follows (Nugent et al., 2000):

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.

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. The majority of entrapped chum salmon (63.1%) were found at sites with substrate embeddedness of 25 to 50% fines (code 2, Figure 18). The single chum mortality was found at an entrapment site with a substrate embeddedness of 50 to 75% (code 3).

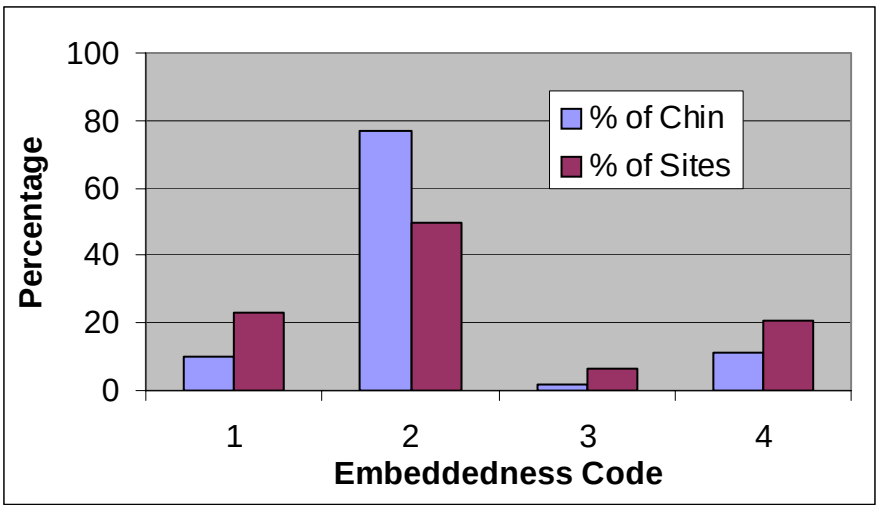
Figure 18: Degrees of substrate embeddedness at chum entrapment sites



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. The majority of stranded chum salmon (73.9%) were found at sites with substrate embeddedness of 25 to 50% fines (code 2). Ninety-eight and one half percent of all stranded chum salmon were mortalities.

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 entrapped chinook (76.9%) occurred in sites with substrate embeddedness of 25 to 50% (code 2) (Figure 19). The 28 chinook entrapment mortalities were nearly evenly split between sites with a substrate embeddedness of 0 to 25%, 25 to 50%, or 50 to 75% (codes 1, 2, or 3).

Figure 19: Degrees of substrate embeddedness at chinook entrapment sites

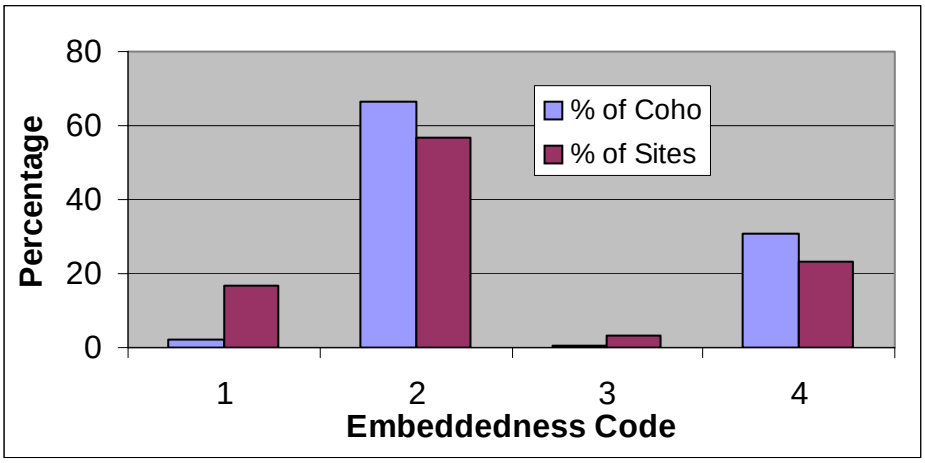


The mean and median number of chinook salmon per survey site found at stranding sites with various degrees of substrate embeddedness are listed in the last two rows of Table B20. The majority of stranded chinook (73.8%) occurred in sites with substrate

embeddedness of 25 to 50% (code 2). Ninety-seven percent of all stranded chinook were mortalities.

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 entrapped coho (66.7%) occurred at sites with a substrate embeddedness of 25 to 50% (code 2) (Figure 20). The only coho mortality occurred at an entrapment site with a substrate embeddedness of 50 to 75%.

Figure 20: Degrees of substrate embeddedness at coho entrapment sites



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. The majority of stranded coho sampled (93.5%) occurred at sites with substrate embeddedness of 25 to 50% (Code 2). All stranded coho were mortalities.

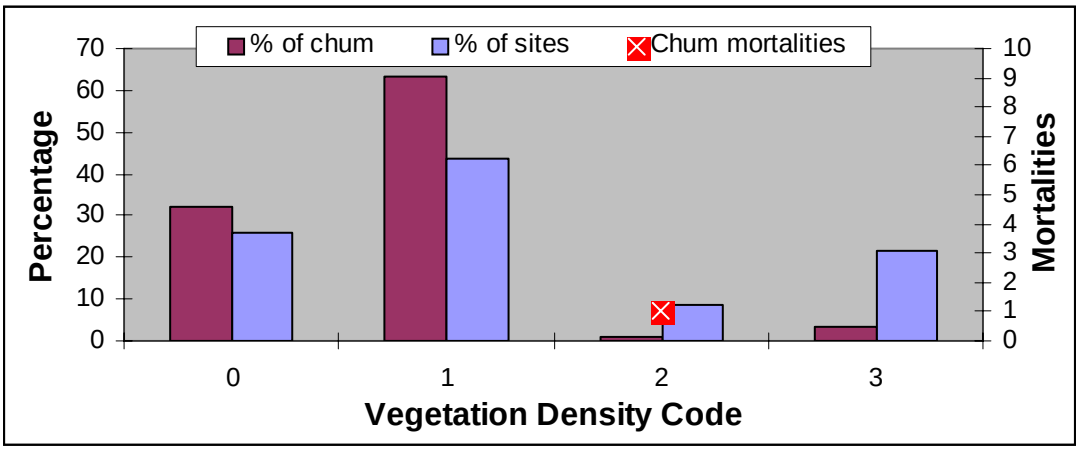
8. Vegetation Density

The amount of substrate concealed by vegetation was estimated visually. The codes are defined as follows (modified from Nugent et al., 2000):

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.

During the year 2004, entrapments with medium and dense vegetation contained primarily aquatic plants, including algae. Chum, chinook, and coho salmon were all found in areas of all four vegetation densities. The greatest numbers of entrapped chum salmon (317) were found at sites with sparse vegetation (code1, Table B23). The largest percentage of chum entrapment sites had sparse vegetation (Figure 21). The only chum mortality discovered in an entrapment was found at a site with medium vegetation.

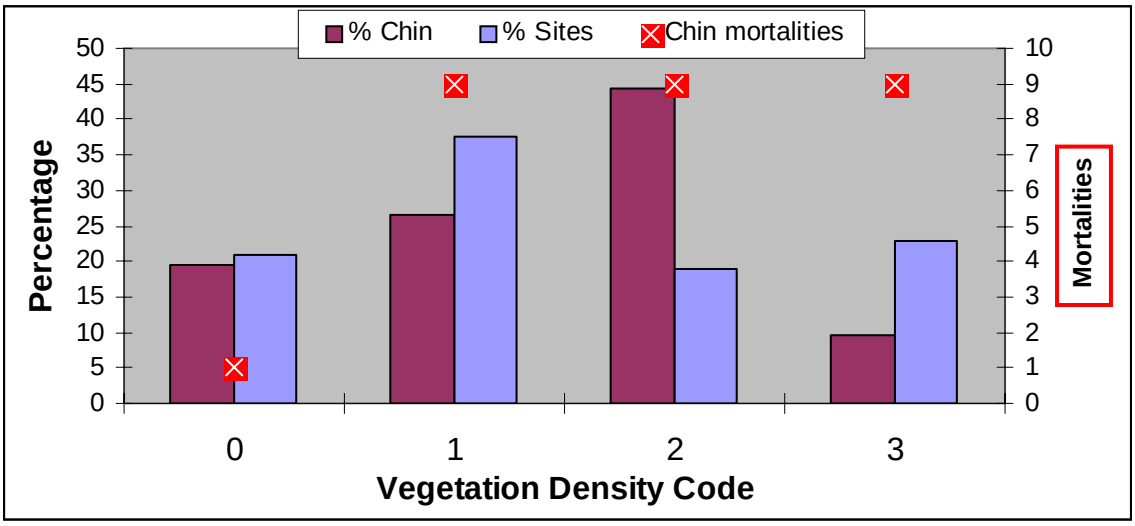
Figure 21: Degrees of vegetation density within chum entrapments



The greatest numbers of stranded (those found out of water) chum salmon (80.6%) were found in sites with sparse vegetation (code 1, Table B24).

The greatest numbers of entrapped chinook salmon (2,755) were found at sites with medium vegetation densities (codes 2, Table B25). The majority of chinook entrapment sites were in areas of sparse vegetation (code 1, Figure 22).

Figure 22: Degrees of vegetation density within chinook entrapments

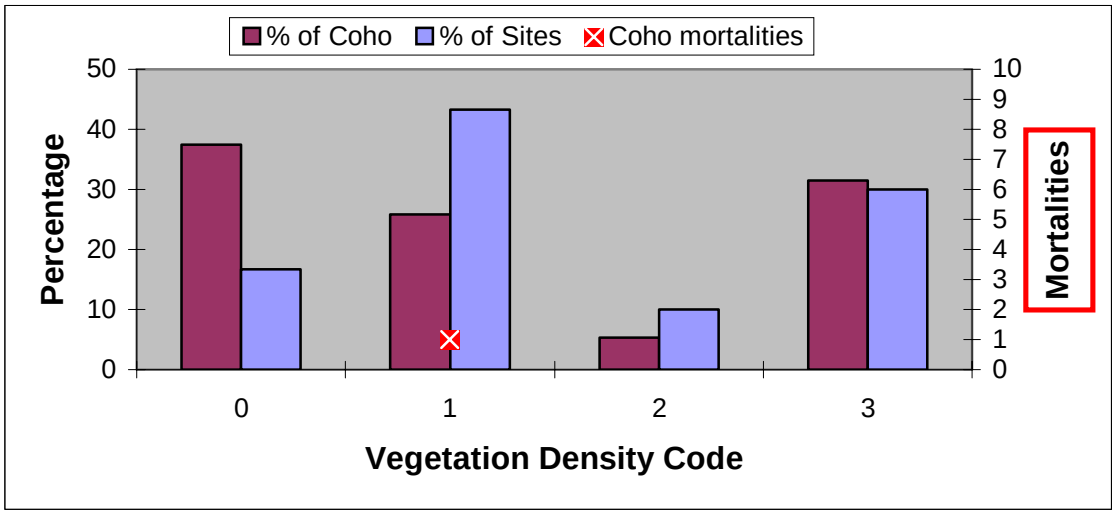


Of the 28 sampled chinook mortalities discovered in entrapments, 27 were equally divided among sites with sparse, medium, and dense vegetation (Figure 22, Table B25).

The greatest numbers of stranded chinook (77.9%) were also found at sites with sparse vegetation (code 1, Table B26).

The greatest numbers of entrapped coho (171) were found at sites with no vegetation. (Code 0, Figure 23, Table B27). The greatest numbers of stranded coho (89) were found at sites with sparse vegetation (code 1, Table B28).

Figure 23: Degrees of vegetation density within coho entrapments



The only known coho entrapment mortality was discovered in an entrapment containing sparse vegetation.

9. Temperature

Two entrapment temperatures were taken, one at the beginning of the sample and one at the end. In most cases, the two entrapment temperatures were identical because of a short time interval between measurements 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. 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.

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 84ºF. Of the 7177 sampled juvenile salmon found in entrapments, 30 (4.2%) were found dead, and of those, 29 were found in water exceeding 78ºF. It is likely that thermal poisoning was the cause of 96.7% of the known entrapment mortalities.

In addition to the 29 known salmon mortalities attributed to thermal poisoning, it is reasonable to assume that an added 558 juvenile salmon would have died if not for sampler intervention. On 4/26, 26 live chum, 523 live chinook, and 9 live coho were retrieved from four entrapments with water temperatures that were known to have been in excess of lethal levels after initial sampling but prior to reflooding. These live salmon have been combined with the known mortalities to form the projected mortalities found in Figures 24, 25, and 26.

All of the known thermal mortality was observed on 4/26 when the following environmental factors merged to create lethal entrapments: there was an above average air temperature of 74°F; the entrapments were shallow; solar access to the entrapments was unimpeded; and there was not enough subsurface flow to counteract the effect of solar radiation. During a 30-year period ending in 2000, the average maximum daily

temperature at Bonneville Dam did not reach 74°F until 6/28; the average maximum air temperature for April 26 was 62.4°F; (WRCC). The deepest random depth measured in any of the four entrapments with either known or potential thermal mortality was 7 inches. Clear skies and the absence of shade allowed solar radiation to penetrate the shallow waters throughout the day, heating the rocky substrate. Tailwater levels were a steady 14.5 to 14.6 feet which kept the water table high enough to prevent dewatering but subsurface flow was either absent or too low to counteract the effects of the solar radiation.

The temperatures of entrapments known to contain any of the three species of juvenile salmon ranged from 43ºF to 84ºF (Table 6). The temperature of the entrapment known to contain the chum mortality ranged from 78ºF-84ºF. The temperature range of entrapments known to contain chinook mortalities was 54ºF to 84ºF. The temperature of the entrapment known to contain the coho mortality ranged from 78ºF-84ºF.

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	NA	43°F-55°F
March	54°F-55°F	53°F-66°F
April	76°F-84°F	57°F-68°F
May	NA	59°F-68°F
June	NA	66°F-72°F
July	NA	NA

Temperature data related to the sampled chum entrapment mortality is found in Figure 24 and Table B29.

Mortality of chinook salmon sampled at entrapment sites was plotted against three temperature measurements (Figure 25). Air and entrapment temperatures had a correlation coefficient of .962559. River and entrapment temperatures had a correlation coefficient of .981694. The number of chinook mortalities and entrapment temperature had a correlation coefficient of .591041. Peak mortality was observed on April 26 (Table B30).

Temperature data related to the sampled coho entrapment mortality is found in Figure 26 and Table B31.

Figure 24. Mortality of threatened chum salmon and temperature measurements at entrapment sites near the Ives Island of the Columbia River in 2004.

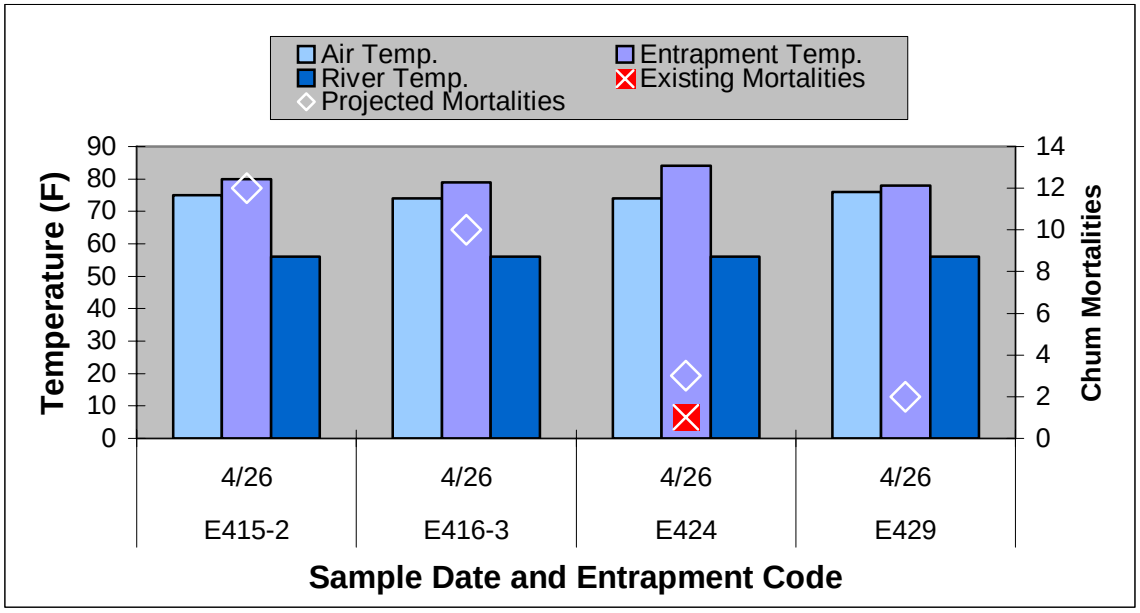


Figure 25. Mortality of chinook salmon and temperatures measurements at entrapment sites near Ives Island of the Columbia River in 2004. One chinook mortality was sampled on 3/7.

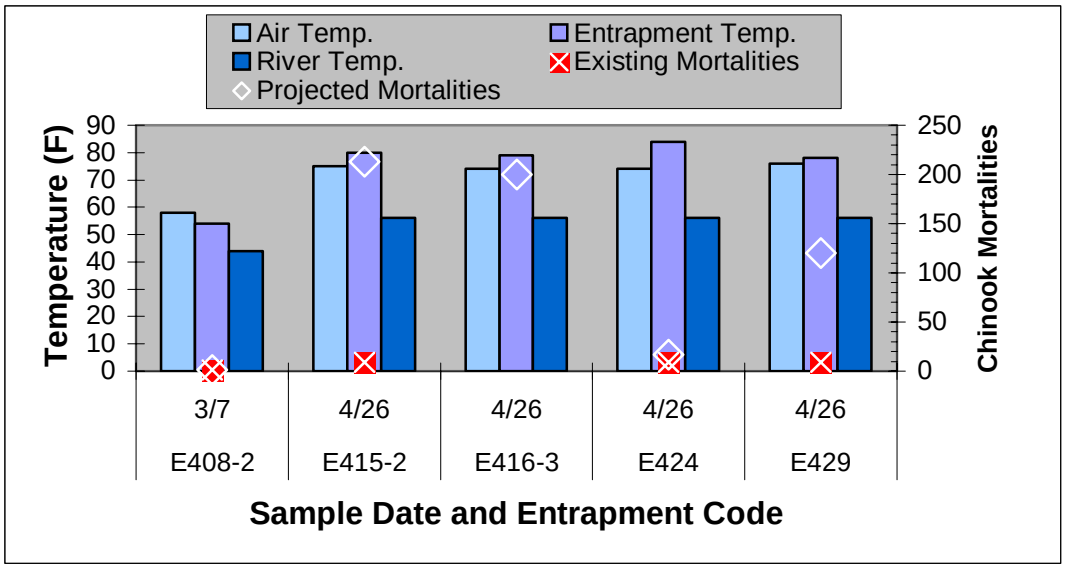
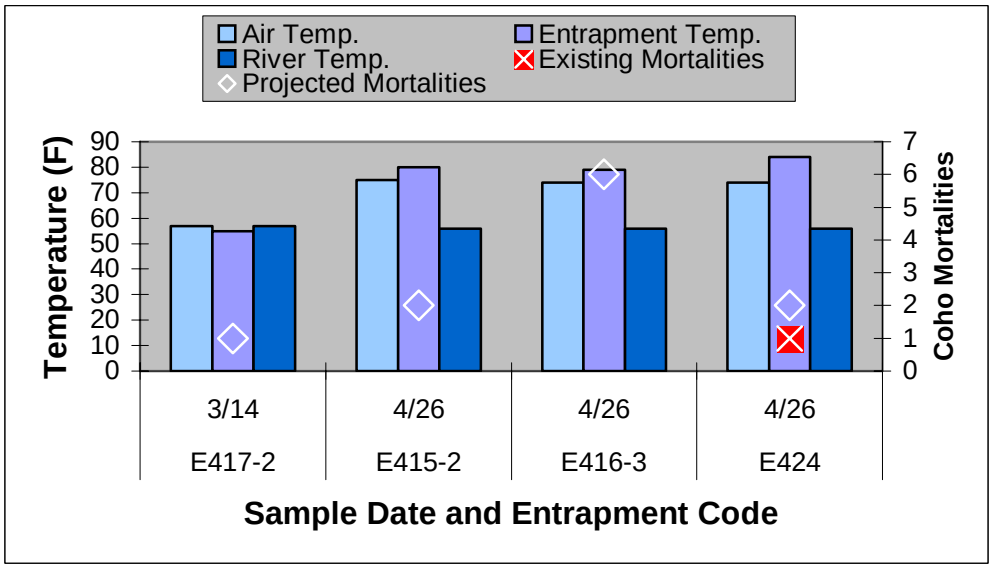


Figure 26. Mortality of coho salmon and temperatures measurements at entrapment sites near Ives Island of the Columbia River in 2004



10. Year-to-Year Comparison

The following is a comparison of the number of fish sampled during each of the five study years followed by a discussion of each of eight major entrapments and possible reasons for the increase in the number of chum, chinook and coho mortalities in 2004.

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

Photograph 3: Major entrapments of 2000, 2001, 2002, 2003 and 2004. (U.S.G.S. photograph taken 8/3/2000)

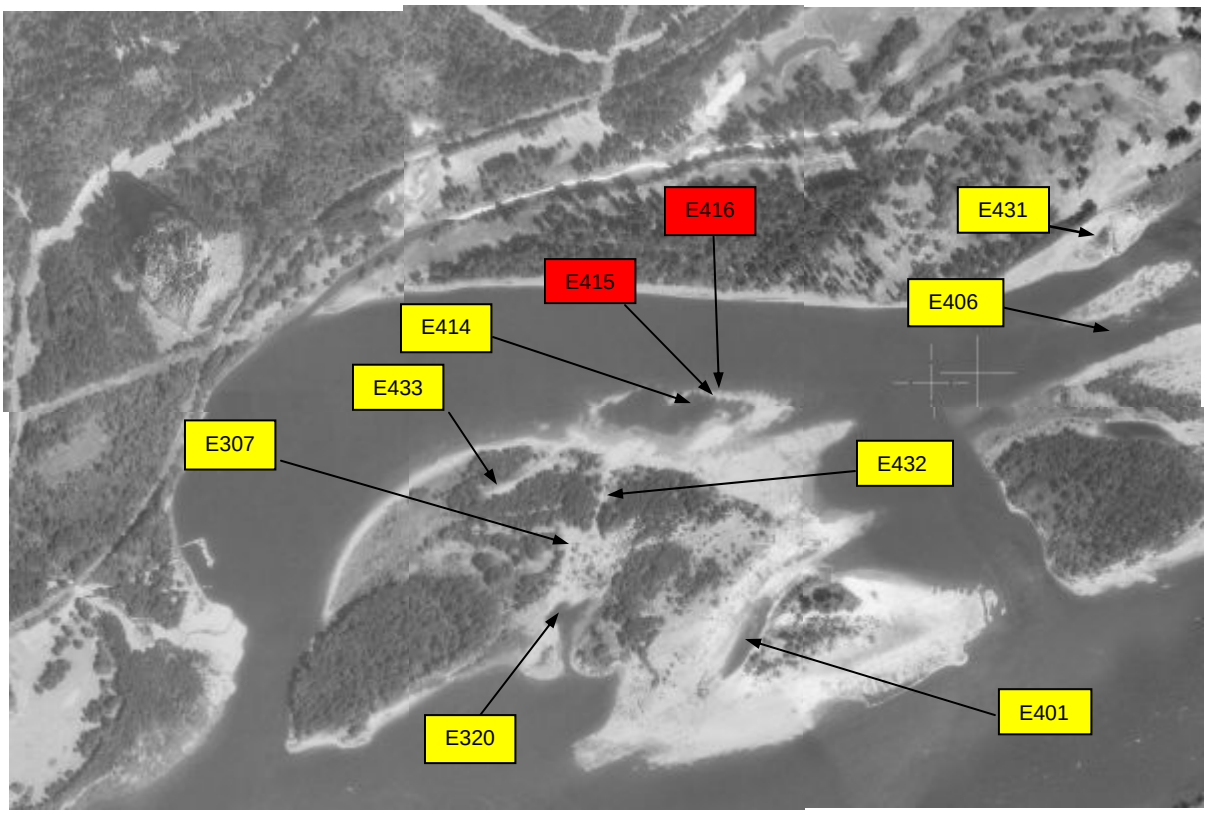


Table 8. Yearly sampling totals per major entrapment

Entrapment and Year	Total Chinook (% of yearly chin)	Total Chum (% of yearly chum)	Total Coho (% of yearly coho)	Dead Chin	Dead Chum	Dead Coho
E307, formally E264 ('02), PIM48 ('00) - (Pierce Island)						
2000	188 (14.3%)	0	0	0	0	0
2001	Dry all season.	NA	NA	NA	NA	NA
2002	28 (2.5%)	0	0	0	0	0
2003	4 (0.1%)	0	1 (0.07%)	0	0	0
2004	Dry all season.	NA	NA	NA	NA	NA
E320, formally 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
E401, formally 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
E406, formally 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
E414, formally 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
E431, formally 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
E432, formally 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
E433, formally E306 ('03), E269 ('02), PIN61 ('00) - (Pierce Island)						
2000	205 (15.6%)	0	0	0	0	0
2001	Dry all season.	NA	NA	NA	NA	NA
2002	124 (11.1%)	0	0	2	0	0
2003	0	0	0	0	0	0
2004	0	0	0	0	0	0

*****In 2002,the sampling crew switched from a 30ft stick sein net to a 100ft beach sein net when sampling E431.

E406 contained 11.6% of all sampled juvenile salmon and 20% of all sampled chum during the 2000, 2001, 2002, 2003, and 2004 sampling periods.

E406 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 E406 but blocked by a broad low-lying berm. In some cases, subsurface flow, probably coming from Hamilton Channel, replenished water within E406 without allowing entrapped salmon an opportunity to escape.

E433 contained 1.7% of all sampled juvenile salmon and 0% of all sampled chum during the 2000, 2001, 2002, 2003, and 2004 sampling periods.

E433 had a maximum surface area of approximately 0.22 acre and was in an isolated clearing west of E432 on the northwest shore of Pierce Island. It is one of the most densely vegetated of all the entrapments and is surrounded by large trees. Relatively high flows are required for surface water to enter it. When flooded, it becomes an enclosed bay. A sandy berm covered by canary grass has formed at its mouth.

E307 contained 1.2% of all sampled juvenile salmon and 0% of all sampled chum during the 2000, 2001, 2002, 2003, and 2004 sampling periods. It was not known to have flooded during the 2004 sample period.

E307 had a maximum surface area of approximately 0.26 acre and was near the middle of Pierce Island just southwest of E432. It receives water from the north via E432 and expels water to the south. The southern border of E307 is formed by what appears to be the remnants of the old Ladzick fishwheel guide (Donaldson). If the remnants were removed, most of E307's water would drain into another entrapment to the south.

E431 contained 11.9% of all sampled juvenile salmon and 5.4% of all sampled chum during the 2000, 2001, 2002, 2003, and 2004 sampling periods.

E431 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).

E432 contained 9.0% of all sampled juvenile salmon and 2.4% of all sampled chum during the 2000, 2001, 2002, 2003, and 2004 sampling periods.

E432 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 in Pierce Island's south central shore. E432 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 E432 would reduce the likelihood of E307 becoming an entrapment.

E401 contained 29.4% of all sampled salmon and 7.5% of all sampled chum during the 2000, 2001,2002, 2003, and 2004 sampling periods.

E401 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. 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.

E414 contained 10.6% of all sampled salmon and 43.6% of all sampled chum during the 2000, 2001, 2002, 2003, and 2004 sampling periods.

E414 had a maximum surface area of approximately 0.91 acre and was a broad shallow pond forming N.E. of E432 along the north central shore of Pierce Island. Water backs into it via a larger and deeper pond to the west 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 E414's shallowness poses a serious threat to entrapped salmon on sunny days. E414 is part of a large area of undulating topography, which includes many other smaller entrapments including E415 and E416, the two entrapments with the greatest number of salmon mortality.

E414 has trapped more threatened chum than any other entrapment during the 4 years of sampling.

E320 contained 5.8% of all sampled salmon and 8.0% of all sampled chum during the 2000, 2001, 2002, 2003, and 2004 sampling periods.

E320 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 entry to E320 is lower than any of the other major entrapments and formation of E320 appears to require tailwater levels somewhere below 12 feet. E320 was never known to have been an entrapment during the 2004 sampling period.

When compared to the 2003 study year, 2004 had a 27.8% (1,702) increase in the overall number of known stranded or entrapped juvenile salmon and a 420% (533) increase in the number of known salmon mortalities. Numbers of entrapped or stranded chum and chinook increased by 47.6% (204) and 58.3% (2,446), respectively. Numbers of entrapped or stranded coho declined by 63.3% (948). Numbers of chum, chinook, and coho mortalities increased by 1771.4% (124), 711.5% (373), and 63.2% (36), respectively.

2004's decrease in number of sampled coho may be because the formation of major entrapments did not coincide with hatchery releases. During 2003, at least 544 of the sampled coho were thought to have been hatchery smolts (Duston, 2004).

Part of the reason for the sharp increase in the 2004 mortality rates may be attributed to the fact that the 2003 study year had relatively low mortality rates. With the exception of coho, all mortality rates were lower in 2003 than during any other study year (Table 9). Nevertheless, the 2004 mortality rate for threatened chum was more than twice that of any other year.

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

To a large degree, the sharp increases in known salmon mortalities can be attributed to two entrapments, E415 and E416 (Photo 3). The combined mortalities retrieved from the areas covered by E415 and E416, including those found stranded after E415 and E416 had drained, were 74 chum, 224 chinook, and 65 coho, in other words, 55.2% of all known mortalities. Entrapment and stranding sites near E415 and E416 thought to be formed by similar tailwater levels accounted for an additional 29 chum, 87 chinook, and 26 coho mortalities. Combining the above sites creates an area that contained 76% of 2004's observed chum mortality and 73% of 2004's total known salmon mortality. Tailwater levels associated with this area are found in Table 5.

Nearly all of 2004's mortalities were attributed to stranding however 29 were known to be the result of thermal poisoning. 2004 was the first year of documented thermal poisoning. Twenty-seven chinook, 1 chum, and 1 coho mortalities were found in entrapment waters exceeding the 79ºF threshold considered lethal to all three species. In addition, 523 chinook, 26 chum, and 9 coho were either still alive at the time of the 79+ºF temperatures or had been removed from the entrapments prior to the temperatures reaching critical stage. If samplers had not collected most of the fish when entrapment temperatures were cooler, an additional 558 juvenile salmon would have been found dead increasing 2004's mortality count by more than 85%.

All of the known thermal mortality was observed on 4/26/2004 when the following environmental factors merged to create lethal entrapments: there was an above average air temperature of 74°F (WRCC); the entrapments were shallow; solar access to the entrapments was unimpeded; and there was not enough subsurface flow to counteract the effect of solar radiation. The lethal melding of the preceding conditions appears to have been rare during the 2000-2004 sampling periods but remains a hazard to juvenile salmon, including threatened chum.

11. Summary

During the 2004 sampling period, 85% of the 7834 sampled fish were chinook salmon, 8% were threatened chum salmon, and 7% were coho salmon. Six hundred fifty-six salmon were observed stranded (dewatered) of which 431 were chinook, 134 were chum, and 92 were coho.

When compared to the 2003 study year, 2004 had a 27.8% (1,702) increase in the overall number of observed juvenile salmon and a 420% (533) increase in the number of observed salmon mortalities. Numbers of entrapped or stranded chum and chinook increased by 47.6% (204) and 58.3% (2,446), respectively. Numbers of entrapped or stranded coho declined by 63.3% (948). Numbers of chum, chinook, and coho mortalities increased by 1771.4% (124), 711.5% (373), and 63.2% (36), respectively.

Mortality and stranding rates were highest for threatened chum salmon, increasing from 1.6% and 1.4% to 20.7% and 21.2%, respectively. Mortality and stranding rates for sampled coho salmon increased from 3.8% and 2.2% to 17.1% and 16.8%, respectively and mortality and stranding rates for chinook salmon increased from 1.4% and 0.6%, in 2003, to 6.7% and 6.5%, respectively. Nineteen of the stranded salmon, 15 chinook and 4 chum, were still alive when sampled.

The majority of the observed salmon mortality came from two entrapments located along the north shore of Pierce Island, E415 and E416 (Photo 3). The combined mortalities retrieved from the E415 and E416 sites, including those found stranded after E415 and E416 had drained, were 74 chum, 224 chinook, and 65 coho, in other words, 55.2% of all known mortalities. Entrapment and stranding sites near E415 and E416 thought to be formed by similar tailwater levels accounted for an additional 29 chum, 87 chinook, and 26 coho mortalities. Combining the above sites creates an area that contained 76% of 2004's observed chum mortality and 73% of 2004's total known salmon mortality. Nearly all of the salmon mortalities found at these sites appear to have become entrapped when tailwater depths dropped to levels between 14.0 and 15.2 feet (Table 5).

During 2004 all known salmon mortalities were observed either along the northern shore of Pierce Island (81%) or along the shorelines between Ives Island and the Pierce Ranch N.W.R. below Hamilton Creek (19%) (Areas E and A, Photo 1). The northern shore of Pierce Island accounted for 81% of the chum mortalities, 77.1% of the chinook mortalities, and 99% of the coho mortalities.

When entrapped and stranded salmon are combined, all but two of the threatened chum salmon were observed in Areas E and A, ninety-nine percent of sampled chinook salmon were fairly evenly distributed between Areas E, A and the wide flood plain cutting through the eastern third of Pierce Island (Area C), and the majority of sampled coho salmon were observed in Areas A, E and near an old fishwheel site between the mouths of Duncan and Woodard Creeks (Area F).

Since the beginning of 2001, 76.8% of the known chum mortalities and 76.4% of all known salmon mortalities were observed along the northern shore of Pierce Island (Area E, Photo 1). Within the same time frame, 22.8% of the known chum mortalities and 18.7% 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).

During 2004, it is believed that dewatering caused over 99% of the chum mortalities and 96% of the total salmon mortality, the rest were believed killed by thermal poisoning. Even though observed thermal poisoning has been rare it has the potential to kill large numbers of juvenile salmon, including threatened chum. It is reasonable to assume that, during 2004, an additional 558 juvenile salmon would have died from thermal poisoning if not for sampler intervention. On 4/26, 26 live chum, 523 live chinook, and 9 live coho were retrieved from four entrapments with water temperatures that were known to have been in excess of lethal levels after initial sampling but prior to reflooding. Sampler intervention also prevented the dewatering of 49 additional chinook and 8 additional chum. If one combines the prevented mortalities with the known mortalities, thermal poisoning would have been the cause of over 45% of the total mortality.

The temperatures of entrapments known to contain any of the three species of juvenile salmon ranged from 43ºF to 84ºF (Table 6). The temperature of the entrapments known to contain chum and coho mortalities ranged from 78ºF to 84ºF. The temperature range of entrapments known to contain chinook mortalities was 54ºF to 84ºF.

At least forty-six percent of all chum (living and dead), 24.1% of all chinook and 48.1% of all coho sampled during 2004 were retrieved from entrapments that were likely to have formed when Bonneville Dam tailwater levels dropped to points between 11.5 and 12.9 feet. An additional 41+% of sampled chinooks were retrieved from entrapments that were likely to have formed when tailwater levels dropped to points between 15.9 and 17.5 feet (Table 4).

Peak numbers of chum and coho were sampled in March and April when tailwater levels ranged between 11.8ft and 19ft. Peak numbers of chinook were sampled in March, April, and May when tailwater levels ranged between 11.8ft and 23.2ft.

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 and coho did not exceed 50mm until after May 1. The weekly mean and median fork lengths for chinook remained below 50mm until the very end of May. Stranded members of all three salmon species had mean fork lengths that were 9% to 11% shorter than those of their entrapped counterparts. Fork lengths of stranded chum and coho never exceeded 49mm. Stranded chinook were known to have fork lengths as long as 69mm but fork lengths greater than 50mm were rare. These findings appear to agree with the conclusions of Nugent et al. (2001) 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.

References

Army Corps of Engineers. Bonneville Dam tailwater tables, 2000, 2001, 2002, 2003, 2004.
http://www.nwdwc.usace.army.mil/cgibin/dataquery.pl?k=Bonneville+dam+Tailwater

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*

Nugent, et al. 2001. 1998 Evaluation of Juvenile Fall Chinook Stranding on the Hanford Reach of the Columbia River. Washington Department of Fish and Wildlife.

O.D.F.W./ P.S.M.F.C. 2003. Ives Island cumulative juvenile chum and chinook catch, 1999-2004. *http://www.fpc.org/ives_island/Graphs_of_cum_catch.htm*

van der Nald, Spellman, and Clark. 2000. 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, Clark, and Spellman. Clark. 2001. 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.

WRCC (Western Regional Climate Center): *http://www.wrcc.dri.edu/cgi-bin/cliMAIN.pl?orbonn*

Appendix A: Site Coordinates

TABLE A. Year 2004 entrapment locations found near Ives Island on the Columbia River.

Entrapment Locations				Sampling
Entrapment Code	Species Sampled	Latitude	Longitude	Area
E401	chum, chinook, coho	N45.62028	W122.00493	C
E402		N45.62196	W122.00347	C
E403		missing	missing	C
E404		N45.61927	W122.00612	C
E405	chinook	missing	missing	A
E406	chum, chinook, coho	N45.62577	W121.99504	A
E407	chum, chinook	N45.62537	W121.99610	A
E408	chinook	N45.62601	W121.99546	A
E409	chinook, coho	N45.61492	W122.02769	F
E410	chum, chinook, coho	N45.61499	W122.02778	F
E411	chinook	N45.61918	W122.00193	B
E412		N45.62472	W122.00305	E
E413	chum, chinook, coho	N45 37.475	W122 00.521	E
E414	chum, chinook, coho	N45 37.462	W122 00.453	E
E415	chinook	N45.62454	W122.00545	E
E416	chum, chinook, coho	N45.62459	W122.00513	E
E417	chum, chinook, coho	N45.62631	W121.99414	A
E418	chum, chinook, coho	N45.62550	W121.99605	A
E419	chinook, coho	N45.62109	W122.00915	D
E420	chinook	N45.62631	W121.99445	A
E421		N45.62123	W121.99922	B
E422	chinook	N45.62075	W121.99845	B
E423	chum, chinook, coho	N45.62632	W121.99445	A
E424	chum, chinook, coho	N45.62436	W122.00518	E
E425		N45.62171	W122.00432	C
E426		N45.62121	W121.99889	B
E427		N45.62086	W121.99880	B
E428		N45.62088	W121.89858	B
E429	chum, chinook	N45.62454	W122.00367	E
E430	chinook	N45.62458	W122.00479	E
E431	chum, chinook, coho	N45.62751	W121.99550	A
E432	chinook	N45.62288	W122.00868	E
E433		N45.62339	W122.01095	E

TABLE B. Year 2004 stranding locations found near Ives Island on the Columbia River.

Stranding Locations				Sampling
Entrapment Code	Species Sampled	Latitude	Longitude	Area
S401	chinook	N45.62673	W121.99521	A
S402	chinook	N45.62635	W121.99617	A
S403	chinook	N45.61927	W122.00612	C
S404	chinook	N45.62613	W121.99510	A
S405	chinook	N45.62628	W121.99455	A
S406	chinook	N45.62606	W121.99304	A
S407	chinook	N45.62610	W121.99302	A
S408	chinook	N45.62550	W121.99605	A
S409	chum, chinook, coho	N45.62463	W122.00509	E
S410	chum, chinook	N45.62462	W122.00370	E
S411	chinook	N45.62630	W121.99450	A
S412	chum	N45.62537	W121.99613	A
S413	chinook	N45.62455	W121.99802	A
S414	chinook, coho	N45.62461	W122.00335	E
S415	chum, chinook, coho	N45.62454	W122.00545	E
S416	chum, chinook, coho	N45.62442	W122.00518	E
S417	chum, chinook, coho	N45.62459	W122.00513	E
S418	chum, chinook, coho	N45.62459	W122.00483	E
S419	chum, chinook, coho	N45.62462	W122.00364	E
S420	chum, chinook, coho	N45.62538	W121.99613	A
S421	chinook, coho	N45.62464	W122.00498	E
S422	chum, chinook	N45.62445	W122.00511	E
S423	chinook	N45.62450	W122.00898	E
S424	chum, chinook	N45.62415	W122.00641	E
S425	chinook	N45.62454	W122.00545	E
S426	chum, chinook, coho	N45.62459	W122.00513	E
S427	chum	N45.62456	W122.00360	E
S428	chinook	N45.62405	W122.00768	E
S429	chum, chinook	N45.62537	W121.99610	A
S430	chinook	N45.62609	W121.99349	A
S431	chinook	missing	missing	A
S432	chinook	N45.62537	W121.99610	A
S433	chum, chinook	N45.62610	W121.99302	A
S434	chinook	N45.62604	W121.99352	A
S435	chinook	N45.61808	W122.00858	C
S436	chum, chinook, coho	N45.62459	W122.00524	E

S437	chum, chinook, coho	N45.62436	W122.00516	E
S438	chum, chinook, coho	N45.62459	W122.00513	E
S439	chum	N45.62458	W122.00363	E
S440	chinook	N45.62604	W121.99352	B
S441	chinook	N45.62180	W122.00306	C
S442	chum, chinook	missing	missing	A
S443	chinook	N45.62623	W121.99627	A
S444	chum, chinook	N45.62667	W121.99414	A
S445	chum	N45.62638	W121.99570	A
S446	chinook	N45.62699	W121.99365	A
S447	chum, chinook	N45.62679	W121.99532	A
S448	chinook	N45.62352	W122.01263	E
S449	chinook	missing	missing	other
S450	chinook	N45.62087	W122.00011	B
S451	chinook	N45.62220	W122.00390	C
S452	chinook	N45.62165	W122.00327	C
S453	chinook	N45.61914	W122.00621	C
S454	chum, chinook, coho	N45.62453	W122.00537	E
S455	chinook	N45.62260	W122.00884	E
S499	chinook, coho	N45.58181	W122.10473	marker 82

Appendix B: Tables

Table B1: Weekly sampling results of threatened chum salmon, 2004

Week	Stranded		Entrapped		Total Mortalities (Stranded + Entrapped)	Total Chum
	Mortality	Alive	Mortality	Alive		
February 15-21	0	0	0	3	0	3
February 22-28	0	0	0	2	0	2
February 29-March 6	0	0	0	44	0	44
March 7-13	0	0	0	36	0	36
March 14-20	28	0	0	107	28	135
March 21-27	33	0	0	19	33	52
March 28-April 3	14	0	0	0	14	14
April 4-10	2	4	0	0	2	6
April 11-17	48	0	0	257	48	305
April 18-24	4	0	0	0	4	4
April 25-May 1	0	0	1	28	1	29
May 2-8	1	0	0	0	1	1
May 9-15	0	0	0	1	0	1
May 16-22	0	0	0	0	0	0
May 23-29	0	0	0	1	0	1
Total	**130**	**4**	**1**	**498**	**131**	**633**

Table B2. Results of weekly sampling of chinook salmon, 2004

Week	Stranded		Entrapped		Total Mortalities (Stranded + Entrapped)	Total Chinook
	Mortality	Alive	Mortality	Alive		
2/7	1	0	0	17	1	18
2/14	2	0	0	1	2	3
2/21	0	0	0	206	0	206
2/28	1	0	0	1	1	2
3/6	0	0	0	519	0	519
3/13	15	0	1	252	16	268
3/20	65	0	0	484	65	549
3/27	138	0	0	74	138	212
4/3	52	0	0	5	52	57
4/10	25	7	0	18	25	50
4/17	79	1	0	836	79	916
4/24	12	7	0	0	12	19
5/1	0	0	27	1343	27	1370
5/8	3	0	0	1	3	4
5/15	17	0	0	890	17	907
5/22	4	0	0	1370	4	1374
5/29	1	0	0	75	1	76
6/5	0	0	0	0	0	0
6/12	0	0	0	2	0	2
6/19	0	0	0	0	0	0
6/26	1	0	0	99	1	100
Total	**416**	**15**	**28**	**6092**	**444**	**6652**

Table B3. Results of weekly sampling of coho salmon, 2004

Week	Stranded		Entrapped		Total Mortalities (Stranded + Entrapped)	Total Coho
	Mortality	Alive	Mortality	Alive		
February 1-7	0	0	0	19	0	19
February 8-14	0	0	0	0	0	0
February 15-21	0	0	0	20	0	20
February 22-28	0	0	0	0	0	0
February 29-March 6	0	0	0	62	0	62
March 7-13	0	0	0	31	0	31
March 14-20	17	0	0	195	17	212
March 21-27	60	0	0	66	60	126
March 28-April 3	6	0	0	0	6	6
April 4-10	0	0	0	0	0	0
April 11-17	9	0	0	42	9	51
April 18-24	0	0	0	0	0	0
April 25-May 1	0	0	1	13	1	14
May 2-8	0	0	0	0	0	0
May 9-15	0	0	0	3	0	3
May 16-22	0	0	0	4	0	4
May 23-29	0	0	0	1	0	1
Total	**92**	**0**	**1**	**456**	**93**	**549**

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. (t) denotes thermal poisoning mortality. (*) Denotes fish that would have become dewatered. (pt) denotes fish that would have died from thermal poisoning.

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
S408	3/15/04	12.4-12.0	0	4	0	0	0	0
S402	2/9/04	12.4-12.1	0	1	0	0	0	0
S403	2/9/04	12.4-12.1	0	1	0	0	0	0
S499	3/16/04	12.8-12.3	0	3	1	0	0	0
E417-2	3/14/04	14.3-12.0	0	0	1	1*	7*	0
E418	3/14/04	14.3-12.0	0	0	0	4*	7*	0
S407	3/14/04	14.3-12.0	0	1	0	0	0	0
S449	4/19/04	14.4-14.1	0	1	0	0	0	0
S425	3/28/04	14.5-12.3	0	3	0	0	0	0
S426	3/28/04	14.5-12.3	4	26	6	0	0	0
S427	3/28/04	14.5-12.3	2	0	0	0	0	0
S428	3/28/04	14.5-12.3	0	1	0	0	0	0
S429	3/28/04	14.5-12.3	8	21	0	0	0	0
S430	3/28/04	14.5-12.3	0	1	0	0	0	0
S415	3/21/04	14.6-11.9	5	48	9	0	0	0
S416	3/21/04	14.6-11.9	6	18	16	0	0	0
S417	3/21/04	14.6-11.9	7	38	25	0	0	0
S418	3/21/04	14.6-11.9	1	5	4	0	0	0

S419	3/21/04	14.6-11.9	3	8	3	0	0	0
S420	3/21/04	14.6-11.9	8	12	1	0	0	0
S431	4/4/04	14.8-13.2	0	2	0	0	0	0
S432	4/4/04	14.8-13.2	0	1	0	0	0	0
S433	4/4/04	14.8-13.2	4	20	0	2	7	0
S434	4/11/04	14.8-13.2	0	1	0	0	1	0
S435	4/11/04	14.8-13.2	0	1	0	0	0	0
S440	4/4/04	14.8-13.2	0	2	0	0	0	0
S436	4/14/04	14.9-13.5	7	23	3	0	0	0
S437	4/14/04	14.9-13.5	5	4	1	0	0	0
S438	4/14/04	14.9-13.5	35	50	5	0	0	0
S439	4/14/04	14.9-13.5	1	0	0	0	0	0
E408-2	3/7/04	15.2-12.1	0	1	0	0	0	0
E415	3/7/04	15.2-12.1	0	0	0	0	5*	0
S405	3/7/04	15.2-12.1	0	2	0	0	0	0
S406	3/7/04	15.2-12.1	0	13	0	0	0	0
S401	2/4/04	15.5-14.0	0	1	0	0	0	0
S421	3/23/04	15.6-12.1	0	4	2	0	0	0
S422	3/23/04	15.6-12.1	2	3	0	0	0	0
S423	3/23/04	15.6-12.1	0	1	0	0	0	0
S424	3/23/04	15.6-12.1	1	1	0	0	0	0
S404	2/26/04	15.6-12.3	0	1	0	0	0	0
S409	3/17/04	15.7-12.4	12	18	13	0	0	0
S410	3/17/04	15.7-12.4	10	21	0	0	0	0
S411	3/17/04	15.7-12.4	0	2	0	0	0	0
S412	3/17/04	15.7-12.4	2	0	0	0	0	0
S413	3/17/04	15.7-12.4	0	1	0	0	0	0
S414	3/17/04	15.7-12.4	0	1	1	0	0	0
S454	3/17/04	15.7-12.4	4	14	2	0	0	0
S446	5/2/04	16.4-14.8	0	2	0	0	0	0
S447	5/2/04	16.4-14.8	1	1	0	0	0	0
E415-2	4/26/04	16.5-14.5	0	9t	0	12pt	204pt	2pt
E416-3	4/26/04	16.5-14.5	0	0	0	10pt	200pt	6pt
E424	4/26/04	16.5-14.5	1t	9t	1t	2pt	8pt	1pt
E429	4/26/04	16.5-14.5	0	9t	0	2pt	111pt	0
S441	4/18/04	18.2-14.2	0	1	0	0	0	0
S442	4/18/04	18.2-14.2	2	5	0	0	0	0
S443	4/18/04	18.2-14.2	0	3	0	0	0	0
S444	4/18/04	18.2-14.2	1	3	0	0	7	0
S445	4/18/04	18.2-14.2	1	0	0	0	0	0
S455	6/20/04	18.4-14.9	0	1	0	0	0	0
S452	5/19/04	18.6-15.5	0	4	0	0	0	0
S453	5/26/04	19.2-17.3	0	1	0	0	0	0
S450	5/13/04	19.7-18.3	0	1	0	0	0	0
S451	5/13/04	19.7-18.3	0	1	0	0	0	0
S448	5/12/04	20.1-17.6	0	15	0	0	0	0

Table B5. Fork length summary of entrapped chum salmon, 2004

Week Ending	Number of Chum	Fork Length			
		Median	Mean	Minimum	Maximum
2/7/2004	0				
2/14/2004	0				
2/21/2004	3	41	41	40	42
2/28/2004	2	38	38	38	38
3/6/2004	44	42	41	35	49
3/13/2004	36	41	41	37	48
3/20/2004	107	43	43	36	54
3/27/2004	19	45	45	37	52
4/3/2004	0				
4/10/2004	0				
4/17/2004	257	45	46.6	37	63
4/24/2004	0				
5/1/2004	29	52	50.9	46	57
5/8/2004	0				
5/15/2004	1	42	42	42	42
5/22/2004	0				
5/29/2004	1	72	72	72	72

Table B6. Fork Length summary of entrapped chinook salmon, 2004

Week Ending	Number of Chinook	Fork Length			
		Median	Mean	Minimum	Maximum
2/7/2004	17	40	41	37	47
2/14/2004	1	38	38	38	38
2/21/2004	206	40	41	37	56
2/28/2004	1	37	37	37	37
3/6/2004	519	43	44	33	63
3/13/2004	253	43	46	37	70
3/20/2004	484	43	45	34	69
3/27/2004	74	46	49	35	74
4/3/2004	5	38	38.6	37	42
4/10/2004	18	39	40.2	36	56
4/17/2004	836	43	44.6	36	66
4/24/2004	0				
5/1/2004	1370	43	44	36	96
5/8/2004	1	36	36	36	36
5/15/2004	890	44	45.1	36	87
5/22/2004	1370	47	47.3	37	97
5/29/2004	75	50	52.9	39	82
6/5/2004	0				
6/12/2004	2	48	48	41	55
6/19/2004	0				
6/26/2003	99	64	64.5	45	84

Table B7. Fork Length summary of entrapped coho salmon, 2004

Week Ending	Number of Coho	Fork Length			
		Median	Mean	Minimum	Maximum
2/7/2004	19	108	94	37	121
2/14/2004	0				
2/21/2004	20	39	38	34	41
2/28/2004	0				
3/6/2004	62	39	44	34	102
3/13/2004	31	39	39	36	58
3/20/2004	195	38	38	33	48
3/27/2004	66	38	38	33	48
4/3/2004	0				
4/10/2004	0				
4/17/2004	42	38	39.6	34	116
4/24/2004	0				
5/1/2004	14	42	52.3	36	123
5/8/2004	0				
5/15/2004	3	57	53	44	58
5/22/2004	4	59	55.3	40	63
5/29/2004	1	46	46	46	46

Table B8. Observed fork length summary of threatened chum salmon at stranding sites near Ives Island in 2004.

Week Ending	Number of Chum	Fork Length			
		Median	Mean	Minimum	Maximum
3/20/2004	28	41.5	41.5	36	49
3/27/2004	33	39	39	36	44
4/3/2004	14	40	40	38	42
4/10/2004	6	40	40.5	38	43
4/17/2004	48	40	40.5	36	48
4/24/2004	4	40.5	41.3	38	46
5/1/2004	0				
5/8/2004	1	43	43	43	43

Table B9. Observed fork length summary of chinook salmon at stranding sites near Ives Island in 2004.

Week Ending	Number of Chin	Fork Length			
		Median	Mean	Minimum	Maximum
2/7/2004	1	38	38	38	38
2/14/2004	2	38.5	38.5	37	40
2/21/2004	0				
2/28/2004	1	39	39	39	39
3/6/2004	0				
3/13/2004	15	42	45	38	60
3/20/2004	65	41	43	34	69
3/27/2004	138	40	41	36	62
4/3/2004	52	40	41	36	54
4/10/2004	32	40	40.2	36	44
4/17/2004	80	40	40.6	37	49
4/24/2004	19	42	41.8	37	48
5/1/2004	0				
5/8/2004	3	40	41.7	38	47
5/15/2004	17	42	42.4	36	48
5/22/2004	4	44	46.5	42	56
5/29/2004	1	49	49	49	49
6/5/2004	0				
6/12/2004	0				
6/19/2004	0				
6/26/2003	1	55	55	55	55

Table B10. Observed fork length summary of coho salmon at stranding sites near Ives Island in 2004

Week Ending	Number of Coho	Fork Length			
		Median	Mean	Minimum	Maximum
3/20/2004	17	38	39	33	48
3/27/2004	60	36.5	37	33	41
4/3/2004	6	38	37.5	32	40
4/10/2004	0				
4/17/2004	9	37	38.4	35	45

Key to dominant substrate codes

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 chum salmon found on entrapment sites marked by a particular dominant substrate near Ives Island in 2004. Numbers in ( ) represent mortalities.

Site Code	Substrate Codes				
	1	5	6	7	8
E401-3		2			
E406				3	
E406-2				43	
E406-3				28	
E406-4				84	
E407			2		
E410-3	4				
E410-4	8				
E413-2	156				
E414		1			
E414-2		8			
E414-3		14			
E414-4		11			
E414-5		99			
E415-2				12	
E416-4				10	
E417-2					1
E418				4	
E423				2	
E424			3 (1)		
E429				2	
E431					1
E431-3					1
Total Number	**168**	**135**	**5 (1)**	**188**	**3**
Mean Number per Site	**56**	**22.5**	**2.5**	**20.9**	**1**
Median Number per Site	**8**	**9.5**	**2.5**	**10**	**1**

Table B12. Number of stranded chum salmon found on sites marked by a particular dominant substrate near Ives Island in 2004. 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
S409		12 (12)			
S410				10 (10)	
S412		2 (2)			
S415				5 (5)	
S416		6 (6)			
S417		7 (7)			
S418			1 (1)		
S419				3 (3)	
S420			8 (8)		
S422		2 (2)			
S424	1 (1)				
S426		4 (4)			
S427				2 (2)	
S429			8 (8)		
S433				6 (2)	
S436				7 (7)	
S437			5 (5)		
S438		35 (35)			
S439				1 (1)	
S442			2 (2)		
S444					1 (1)
S445				1 (1)	
S447				1 (1)	
S454				4 (4)	
Total Number	**1 (1)**	**68 (68)**	**24 (24)**	**40 (36)**	**1 (1)**
Mean Number per Site	**1**	**9.7**	**4.8**	**4**	**1**
Median Number per Site	**1**	**6**	**5**	**3.5**	**1**

Table B13. Number of entrapped chinook salmon found on sites marked by a particular dominant substrate near Ives Island in 2004. Numbers in ( ) represent mortalities (key precedes Table B11)

Site Code	Substrate Codes				
	1	5	6	7	8
E401		17			
E401-3		691			
E401-4		128			
E401-5		739			
E401-6		1139			
E401-7		13			
E405				1	
E406				206	
E406-2				496	
E406-3				146	
E406-4				347	
E407			1		
E408-2				1 (1)	
E409-2					6
E410	2				
E410-2	1				
E410-3	10				
E410-4	13				
E411-2	1				
E413	2				
E413-2	2				
E413-2	675				
E414		19			
E414-2		89			
E414-3		105			
E414-4		58			
E414-5		137			
E415				5	
E415-2				213 (9)	
E416		8			
E416-2	1				
E416-3				200	
E417					1
E417-2					7
E417-3					3
E418				7	
E419	2				
E420					5
E422			18		
E423				23	
E424			17 (9)		
E429				120 (9)	
E430				1	
E431					151
E431-2					231
E431-3					75
E432-2		2			
E432-3		86			
Total Number	**709**	**3231**	**36 (9)**	**1766 (19)**	**479**
Mean Number per Site	**70.9**	**230.8**	**12**	**135.8**	**59.9**
Median Number per Site	**2**	**87.5**	**17**	**120**	**6.5**

Table B14. Number of stranded chinook salmon found on sites marked by a particular dominant substrate near Ives Island in 2004. Accompanying entrapment codes identify the stranding site as a dewatered entrapment. Numbers in ( ) represent mortalities (key precedes Table B11).

Site Code	Substrate Codes					
	1	4	5	6	7	8
S401					1 (1)	
S402					1 (1)	
S403			1 (1)			
S404					1 (1)	
S405						2 (2)
S406					13 (13)	
S407					1 (1)	
S408					4 (4)	
S409			18 (18)			
S410					21 (21)	
S411					2 (2)	
S413	1 (1)					
S414					1 (1)	
S415					48 (48)	
S416			18 (18)			
S417			38 (38)			
S418				5 (5)		
S419					8 (8)	
S420				12 (12)		
S421			4 (4)			
S422			3 (3)			
S423			1 (1)			
S424	1 (1)					
S425					3 (3)	
S426			26 (26)			
S428	1 (1)					
S429				21 (21)		
S430						1 (1)
S431					2 (2)	
S432				1 (1)		
S433					27 (20)	
S434		2 (1)				
S435				1 (1)		
S436					23 (23)	
S437				4 (4)		
S438			50 (50)			
S440				2 (2)		
S441		1 (1)				
S442				5 (5)		
S443				2 (2)		
S444						10 (3)
S446		2 (2)				
S447					1 (1)	
S448	15 (15)					
S449	1 (1)					
S450					1 (1)	
S451		1 (1)				
S452				4 (4)		
S453				1 (1)		
S454					14 (14)	
S455			1 (1)			
S499	3 (3)					
Total Number	**22 (22)**	**6 (5)**	**160 (160)**	**58 (58)**	**172 (165)**	**13 (6)**
Mean Number per Site	**3.7**	**1.5**	**16**	**5.3**	**9.6**	**4.3**
Median Number per Site	**1**	**1.5**	**11**	**4**	**2.5**	**2**

Table B15. Number of entrapped coho salmon found on entrapment sites marked by a particular dominant substrate near Ives Island in 2004. Numbers in ( ) represent mortalities (key precedes Table B11).

Site Code	Substrate Codes				
	1	5	6	7	8
E401		19			
E401-3		3			
E401-4		1			
E406				20	
E406-2				40	
E406-3				13	
E406-4				97	
E409					2
E409-2					6
E410	9				
E410-2	4				
E410-3	55				
E410-4	60				
E413	7				
E413-2	3				
E414		4			
E414-2		12			
E414-3		34			
E414-4		6			
E414-5		38			
E415-2				2	
E416		2			
E416-4				6	
E417-2					1
E419	2				
E423				1	
E424			2 (1)		
E431					3
E431-2					4
E431-3					1
Total Number	**140**	**119**	**2 (1)**	**179**	**17**
Mean Number per Site	**20**	**13.2**	**2**	**25.6**	**2.8**
Median Number per Site	**7**	**6**	**2**	**13**	**2.5**

Table B16. Number of stranded coho salmon found on sites marked by a particular dominant substrate near Ives Island in 2004. 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
S409		13 (13)		
S414				1 (1)
S415				9 (9)
S416		16 (16)		
S417		25 (25)		
S418			4 (4)	
S419				3 (3)
S420			1 (1)	
S421		2 (2)		
S426		6 (6)		
S436				3 (3)
S437			1 (1)	
S438		5 (5)		
S454				2 (2)
S499	1 (1)			
Total Number	**1 (1)**	**67 (67)**	**6 (6)**	**18 (18)**
Mean Number per Site	**1**	**11.2**	**2**	**3.6**
Median Number per Site	**1**	**9.5**	**1**	**3**

Key to embeddedness codes:

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 2004. Numbers in ( ) represent mortalities.

Site Code	Embeddedness Code			
	1	2	3	4
E401-3		2		
E406		3		
E406-2		43		
E406-3		28		
E406-4		84		
E407	2			
E410-3				4
E410-4				8
E413-2				156
E414		1		
E414-2		8		
E414-3		14		
E414-4		11		
E414-5		99		
E415-2		12		
E416-4		10		
E417-2	1			
E418	4			
E423	2			
E424			3 (1)	
E429	2			
E431	1			
E431-3	1			
Total number	13	315	3(1)	168
Mean number per site	1.9	26.3	3	56
Median number per site	2	11.5	3	8

Table B18. Number of threatened chum salmon found at stranding sites with a given substrate embeddedness near Ives Island of the Columbia River in 2004. 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
S409		12 (12)		
S410		10 (10)		
S412			2 (2)	
S415		5 (5)		
S416		6 (6)		
S417		7 (7)		
S418		1 (1)		
S419	3 (3)			
S420	8 (8)			
S422		2 (2)		
S424				1 (1)
S426		4 (4)		
S427	2 (2)			
S429	8 (8)			
S433		6 (4)		
S436		7 (7)		
S437			5 (5)	
S438		35 (35)		
S439	1 (1)			
S442			2 (2)	
S444	1 (1)			
S445			1 (1)	
S447	1 (1)			
S454		4 (4)		
Total number	24 (24)	99 (97)	10 (10)	1 (1)
Mean number per site	3.4	8.3	2.5	1
Median number per site	2	6	2	1

Table B19. Number of chinook salmon found at entrapment sites with given substrate embeddedness near Ives Island of the Columbia River in 2004. Numbers in ( ) represent mortalities (key precedes Table B17).

Site Code	Embeddedness Code			
	1	2	3	4
E401		17		
E401-3		691		
E401-4		128		
E401-5		739		
E401-6		1139		
E401-7		13		
E405		1		
E406		206		
E406-2		496		
E406-3		146		
E406-4		347		
E407	1			
E408-2	1 (1)			
E409-2		6		
E410				2
E410-2				1
E410-3				10
E410-4				13
E411-2				1
E413				2
E413-2				2
E413-2				675
E414		19		
E414-2		89		
E414-3		105		
E414-4		58		
E414-5		137		
E415		5		
E415-2		213 (9)		
E416		8		
E416-2				1
E416-3		200		
E417	1			
E417-2	7			
E417-3	3			
E418	7			
E419				2
E420		5		
E422		18		
E423	23			
E424			17 (9)	
E429	120 (9)			
E430		1		
E431	151			
E431-2	231			
E431-3	75			
E432-2			2	
E432-3			86	
Total number	620 (10)	4787 (9)	105 (9)	709
Mean number per site	56.4	199.5	35	70.9
Median number per site	7	141.5	17	2

Table B20. Number of chinook salmon found at stranding sites with given substrate embeddedness near Ives Island of the Columbia River in 2004. 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
S401	1 (1)			
S402		1 (1)		
S403				1 (1)
S404	1 (1)			
S405	2 (2)			
S406		13 (13)		
S407	1 (1)			
S408	4 (4)			
S409		18 (18)		
S410		21 (21)		
S411	2 (2)			
S413				1 (1)
S414		1 (1)		
S415		48 (48)		
S416		18 (18)		
S417		38 (38)		
S418		5 (5)		
S419	8 (8)			
S420	12 (12)			
S421		4 (4)		
S422		3 (3)		
S423				1 (1)
S424				1 (1)
S425		3 (3)		
S426		26 (26)		
S428				1 (1)
S429	21 (21)			
S430	1 (1)			
S431		2 (2)		
S432	1 (1)			
S433		27 (20)		
S434			2 (1)	
S435	1 (1)			
S436		23 (23)		
S437			4 (4)	
S438		50 (50)		
S440			2 (2)	
S441			1 (1)	
S442			5 (5)	
S443		2 (2)		
S444	10 (3)			
S446				2 (2)
S447	1 (1)			
S448				15 (15)
S449				1 (1)
S450		1 (1)		
S451			1 (1)	
S452	4 (4)			
S453	1 (1)			
S454		14 (14)		
S455			1 (1)	
S499				3 (3)
Total number	71 (66)	318 (311)	16 (15)	26 (26)
Mean number per site	4.4	15.9	2.3	2.9
Median number per site	2	4.5	2	1

Table B21. Number of coho salmon found at entrapment sites with given substrate embeddedness near Ives Island of the Columbia River in 2004. Numbers in ( ) represent mortalities (key precedes Table B17).

Site Code	Embeddedness Code			
	1	2	3	4
E401		19		
E401-3		3		
E401-4		1		
E406		20		
E406-2		40		
E406-3		13		
E406-4		97		
E409		2		
E409-2		6		
E410				9
E410-2				4
E410-3				55
E410-4				60
E413				7
E413-2				3
E414		4		
E414-2		12		
E414-3		34		
E414-4		6		
E414-5		38		
E415-2		2		
E416		2		
E416-4		6		
E417-2	1			
E419				2
E423	1			
E424			2 (1)	
E431	3			
E431-2	4			
E431-3	1			
Total number	10	305	2(1)	140
Mean number per site	2	17.9	2	20
Median number per site	1	6	2	7

Table B22. Number of coho salmon found at stranding sites with given substrate embeddedness near Ives Island of the Columbia River in 2004. 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
S409		13 (13)		
S414		1 (1)		
S415		9 (9)		
S416		16 (16)		
S417		25 (25)		
S418		4 (4)		
S419	3 (3)			
S420	1 (1)			
S421		2 (2)		
S426		6 (6)		
S436		3 (3)		
S437			1 (1)	
S438		5 (5)		
S454		2 (2)		
S499				1 (1)
Total number	4 (4)	86 (86)	1 (1)	1 (1)
Mean number per site	2	7.8	1	1
Median number per site	2	5	1	1

Key to vegetation density codes

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 2004. Numbers in ( ) represent mortalities.

Site Code	Vegetation Density Code			
	0	**1**	**2**	**3**
E401-3			2	
E406	3			
E406-2	43			
E406-3	28			
E406-4	84			
E407	2			
E410-3				4
E410-4				8
E413-2		156		
E414		1		
E414-2		8		
E414-3		14		
E414-4		11		
E414-5		99		
E415-2		12		
E416-4		10		
E417-2	1			
E418		4		
E423		2		
E424			3 (1)	
E429				2
E431				1
E431-3				1
Total Number	**161**	**317**	**5 (1)**	**16**
Mean Number per Site	**26.8**	**31.7**	**2.5**	**3.2**
Median Number per Site	**15.5**	**10.5**	**2.5**	**2**

Table B24. Number of threatened chum salmon observed at stranding sites with given vegetation densities near Ives Island of the Columbia River in 2004. 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
S409		12 (12)		
S410		10 (10)		
S412	2 (2)			
S415		5 (5)		
S416		6 (6)		
S417		7(7)		
S418		1(1)		
S419		3 (3)		
S420	8 (8)			
S422		2 (2)		
S424			1 (1)	
S426		4 (4)		
S427		2 (2)		
S429	8 (8)			
S433	6 (2)			
S436		7 (7)		
S437		5 (5)		
S438		35 (35)		
S439		1 (1)		
S442		2 (2)		
S444		1 (1)		
S445		1 (1)		
S447	1 (1)			
S454		4 (4)		
Total Number	**25 (25)**	**108 (108)**	**1 (1)**	**0**
Mean Number per Site	**5**	**6**	**0**	**0**
Median Number per Site	**6**	**5.5**	**0**	**0**

Table B25. Number of chinook salmon observed at entrapment sites with given vegetation densities near Ives Island of the Columbia River in 2004. Numbers in ( ) represent mortalities (key precedes Table B23).

Site Code	Vegetation Density Code			
	0	1	2	3
E401			17	
E401-3			691	
E401-4			128	
E401-5			739	
E401-6			1139	
E401-7			13	
E405				1
E406	206			
E406-2	496			
E406-3	146			
E406-4	347			
E407	1			
E408-2	1 (1)			
E409-2				6
E410				2
E410-2				1
E410-3			10	
E410-4				13
E411-2				1
E413		2		
E413-2		2		
E413-2		675		
E414		19		
E414-2		89		
E414-3		105		
E414-4		58		
E414-5		137		
E415		5		
E415-2		213 (9)		
E416		8		
E416-2		1		
E416-3		200		
E417	1			
E417-2	7			
E417-3	3			
E418		7		
E419				2
E420		5		
E422		18		
E423		23		
E424			17 (9)	
E429				120 (9)
E430			1	
E431				151
E431-2				231
E431-3				75
E432-2	2			
E432-2		86		
Total Number	**1210 (1)**	**1653 (9)**	**2755 (9)**	**603 (9)**
Mean Number per Site	**121**	**91.8**	**306.1**	**54.8**
Median Number per Site	**5**	**38.5**	**17**	**6**

Table B26. Number of chinook salmon observed at stranding sites with given vegetation densities near Ives Island of the Columbia River in 2004. Accompanying entrapment codes identify the stranding site as a dewatered entrapment (key precedes Table B23). Numbers in ( ) represent mortalities (key, p. 57).

Site Code	Vegetation Density Code			
	0	1	2	3
S401		1 (1)		
S402	1 (1)			
S403		1 (1)		
S404	1 (1)			
S405	2 (2)			
S406	13 (13)			
S407	1 (1)			
S408				4 (4)
S409		18 (18)		
S410		21 (21)		
S411	2 (2)			
S413				1 (1)
S414		1 (1)		
S415		48 (48)		
S416		18 (18)		
S417		38 (38)		
S418		5 (5)		
S419		8 (8)		
S420	12 (12)			
S421		4 (4)		
S422		3 (3)		
S423			1 (1)	
S424			1 (1)	
S425		3 (3)		
S426		26 (26)		
S428		1 (1)		
S429	21 (21)			
S430	1 (1)			
S431	2 (2)			
S432	1 (1)			
S433	27 (20)			
S434	2 (1)			
S435				1 (1)
S436		23 (23)		
S437		4 (4)		
S438		50 (50)		
S440	2 (2)			
S441		1 (1)		
S442		5 (5)		
S443		2 (2)		
S444		10 (3)		
S446		2 (2)		
S447	1 (1)			
S448		15 (15)		
S449				1 (1)
S450		1 (1)		
S451			1 (1)	
S452	4 (4)			
S453		1 (1)		
S454		14 (14)		
S455		1 (1)		
S499		3 (3)		
Total Number	**93 (85)**	**328 (321)**	**3 (3)**	**7 (7)**
Mean Number per Site	**5.8**	**11.3**	**1**	**1.8**
Median Number per Site	**2**	**4**	**1**	**1**

Table B27. Number of coho salmon observed at entrapment sites with given vegetation densities near the Ives Island of the Columbia River in 2004. Numbers in ( ) represent mortalities (key precedes Table B23).

Site Code	Vegetation Density Code			
	0	1	2	3
E401			19	
E401-3			3	
E401-4		1		
E406	20			
E406-2	40			
E406-3	13			
E406-4	97			
E409				2
E409-2				6
E410				9
E410-2				4
E410-3				55
E410-4				60
E413		7		
E413-2		3		
E414		4		
E414-2		12		
E414-3		34		
E414-4		6		
E414-5		38		
E415-2		2		
E416		2		
E416-4		6		
E417-2	1			
E419			2	
E423		1		
E424		2 (1)		
E431				3
E431-2				4
E431-3				1
Total Number	**171**	**118 (1)**	**24**	**144**
Mean Number per Site	**34.2**	**9.1**	**8**	**16**
Median Number per Site	**20**	**4**	**3**	**4**

Table B28. Number of coho salmon observed at stranding sites with given vegetation densities near the Ives Island of the Columbia River in 2004. 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
S409		13 (13)		
S414		1 (1)		
S415		9 (9)		
S416		16 (16)		
S417		25 (25)		
S418		4 (4)		
S419		3 (3)		
S420	1 (1)			
S421	2 (2)			
S426		6 (6)		
S436		3 (3)		
S437		1 (1)		
S438		5 (5)		
S454		2 (2)		
S499		1 (1)		
Total Number	**3 (3)**	**89 (89)**	**0**	**0**
Mean Number per Site	**1.5**	**6.8**	**0**	**0**
Median Number per Site	**1.5**	**4**	**0**	**0**

Table B29. Chum mortalities and temperature measurements

Sampling Date	Entrapment Code	Mortalities	Projected Mortalities	Entrapment Temp. (F)	Air Temp. (F)	River Temp. (F)
4/26/04	E415-2	0	12	80	75	56
4/26/04	E416-3	0	10	79	74	56
4/26/04	E424	1	2	84	74	56
4/26/04	E429	0	2	78	76	56

Table B30. Chinook mortalities and temperature measurements

Sampling Date	Entrapment Code	Mortalities	Projected Mortalities	Entrapment Temp. (F)	Air Temp. (F)	River Temp. (F)
3/7/04	E408-2	1	1	58	44	54
4/26/04	E415-2	9	213	75	56	80
4/26/04	E416-3	0	200	74	56	79
4/26/04	E424	9	17	74	56	84
4/26/04	E429	9	120	76	56	78