BONNEVILLE POWER ADMINISTRATION

2002 Evaluation of Chum, Chinook and Coho Salmon Entrapment near Ives Island in the Columbia River

Annual Report 2002 October 2003 DOE/BP-00004287-1

This Document should be cited as follows:

Duston, Reed, Jeremy Wilson, "2002 Evaluation of Chum, Chinook and Coho Salmon Entrapment near Ives Island in the Columbia River", 2002 Annual Report, Project No. 199900301, 63 electronic pages, (BPA Report DOE/BP-00004287-1)

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.

2002 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 528.03

ACKNOWLEDGEMENTS

EDITORIAL ASSISTANCE

Chris Murray	Pacific Northwest National Laboratory

FIELD SAMPLING

Rick Heitz	Pacific States Marine Fisheries Commission
Roy Clark	O.D.F.W.
Eric Ollerenshaw	O.D.F.W.

CONTENTS

Appendix A: Site Coordinates

Appendix B: Tables

Additional Tables

FIGURES

Maps

From January to July of 2002, 79 entrapments and 22 stranding sites were examined on the Columbia River near Ives Island, downstream of Bonneville Dam. A total of 2,272 salmonids, consisting of three different species, were collected at these sites (Table 1). The fish sampled during this time were chinook salmon (49%), chum salmon (29%), and coho salmon (22%). The following analysis of the relationship between environmental factors and salmon placed at risk by river level fluctuations focuses on each of these three salmon species.

Table 1. Total number of fish observed during the late winter through early summer sampling period (January 29 – July 23) near Ives Island in 2002.

Common Name	Scientific Name	Entrapped		Stranded		Total Fish
		Mortality	Alive	Mortality	Alive	
Chinook Salmon	Oncorhynchus tshawytscha	21	1059	32	2	1114
Chum Salmon	Oncorhynchus keta	9	597	52	0	658
Coho Salmon	Oncorhynchus kisutch	1	415	84	0	500
Total		31	2071	168	2	2272

1. Methods and Definitions

Because of the relatively small size of the Ives Island / Pierce Island study area, an attempt was made to survey the entire 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 also very 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 25, 2002, and ended on July 23, 2002. The first and last sampling dates on which threatened chum salmon were observed were March 10, 2002, and May 15, 2002, respectively. The weekly sampling results of chum salmon are listed in Table B1 (Appendix B) and plotted in Figure 1. Peak numbers of threatened chum were observed from late March through late April. There were 61 mortalities, approximately 9.3 % of the total number of observed threatened chum salmon.

The first and last sampling dates on which chinook salmon were observed were January 25, 2002 and July 19, 2002, 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 March through mid June. There were 53 mortalities, approximately 4.8% of the total number of observed chinook salmon.

The first and last sampling dates on which coho salmon were observed were March 4, 2002, and May 20, 2002, 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 from the end of March through mid May. There were 85 mortalities, approximately 17% of the total number of observed coho salmon.

Figure 1. Weekly sampling results of threatened chum salmon.

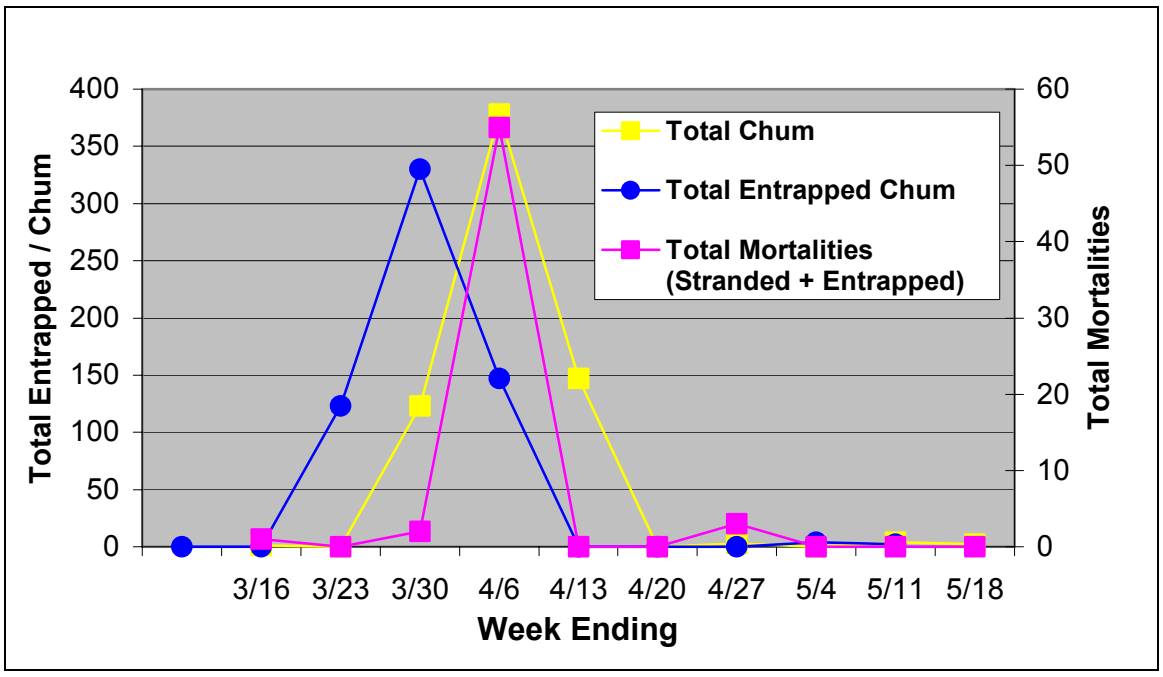


Figure 2. Results of weekly sampling of chinook salmon

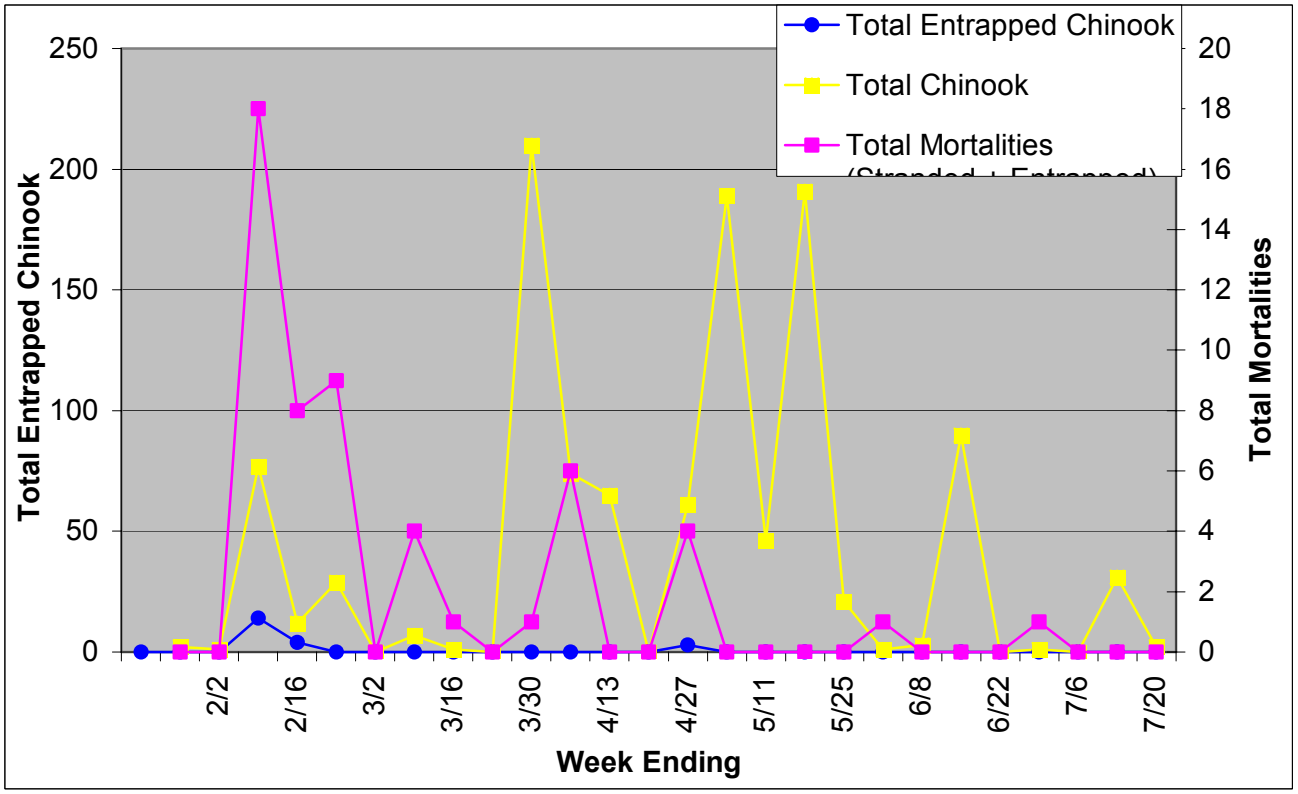
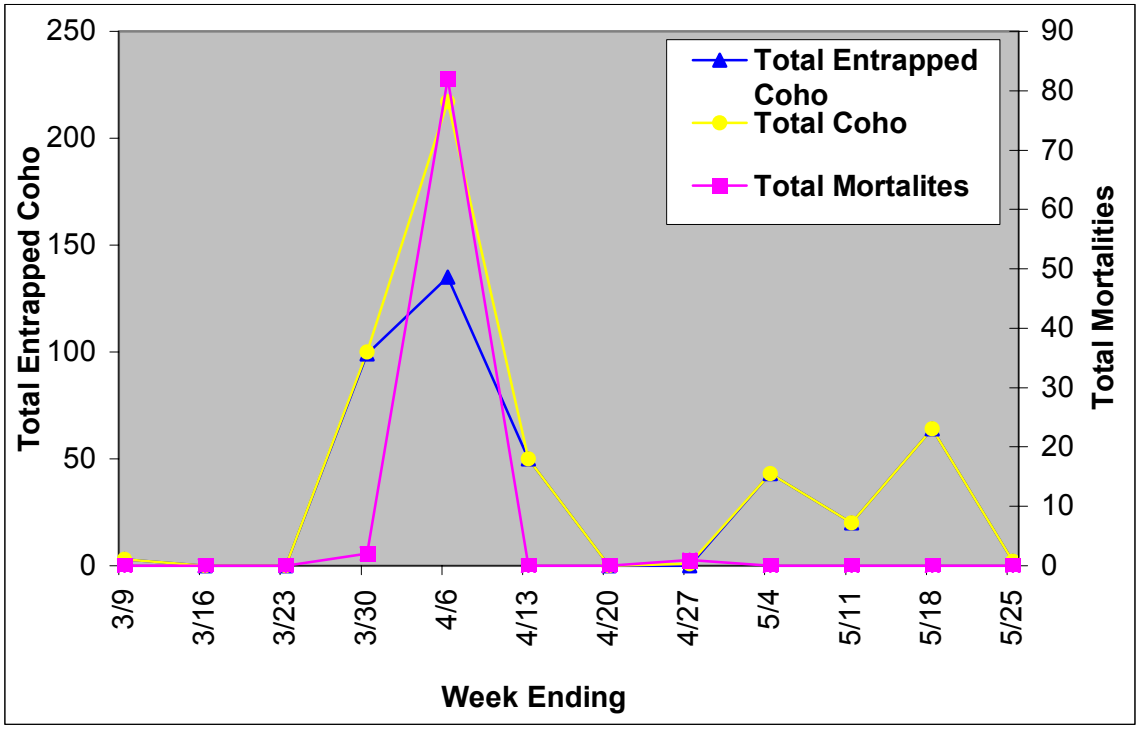


Figure 3. Results of weekly sampling of coho salmon



3. Distribution

Although an attempt was made to survey the entire study area every one to three days, all salmon sampled during 2002 were found within four major sampling areas, designated A, C, D, and E (Map 1, Table 2). Several entrapments were sampled repeatedly as fluctuating water levels continued to replenish then isolate their contents. Subsequent samples are identified in the tables as –2 (2nd sample), -3 (3rd sample), etc. When using cumulative totals for the last 3 years of sampling, 70.1% of all sampled fish were found within four entrapments (Map 2, Table 6). A brief description of each of the four major entrapments follows Map 2.

Entrapped chinook salmon comprised the largest numbers in each of the sampling areas. Coho salmon, as well as threatened chum salmon were only found in Areas A and E. Peak abundances of salmonids sampled were found in Area E (Table 2, Figure 4).

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

Map 1: Sampling Areas: A through F

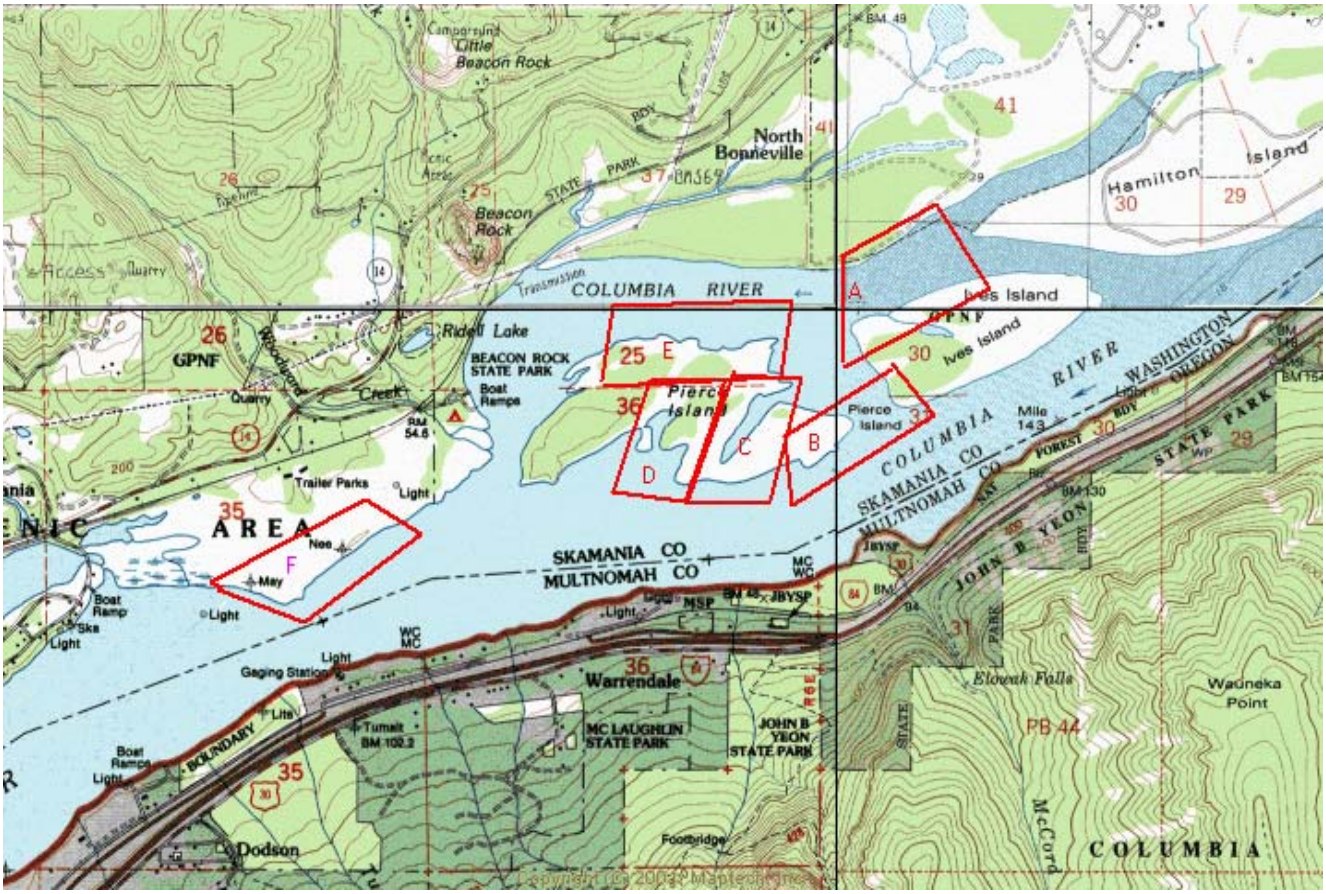


Table 2. Spatial distribution of chinook, coho, and threatened chum salmon

	Sampling Area					
	A	B	C	D	E	F
River Mile (statute miles)	142.35 to 142.75	142.15 to 142.48	141.9 to 142.25	141.77 to 142	141.8 to 142.2	140.7 to 141.7
Entrapped Chum	123	0	0	0	483	0
Stranded Chum	4	0	0	0	48	0
Total Chum	127	0	0	0	531	0
% of all Chum sampled	19.30%	0.00%	0.00%	0.00%	80.70%	0.00%
Entrapped Chinook	362	0	10	28	680	0
Stranded Chinook	4	0	0	0	30	0
Total Chinook	366	0	10	28	710	0
% of all Chin. Sampled	32.90%	0.00%	0.90%	2.50%	63.70%	0.00%
Entrapped Coho	143	0	0	0	273	0
Stranded Coho	1	0	0	0	83	0
Total Coho	144	0	0	0	356	0
% of all Coho Sampled	28.80%	0.00%	0.00%	0.00%	71.20%	0.00%
Total Salmon	637	0	10	28	1597	0
% of all Salmon Sampled	28.00%	0.00%	0.50%	1.20%	70.30%	0.00%

Figure 4. Spatial distribution of chum, chinook, and coho salmon

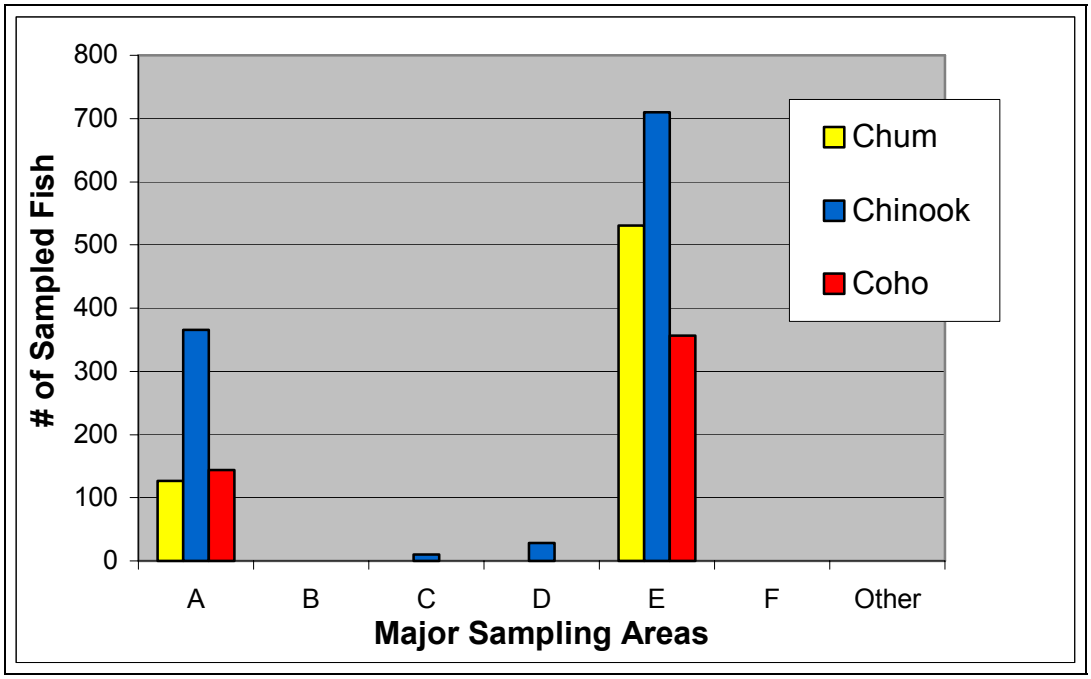
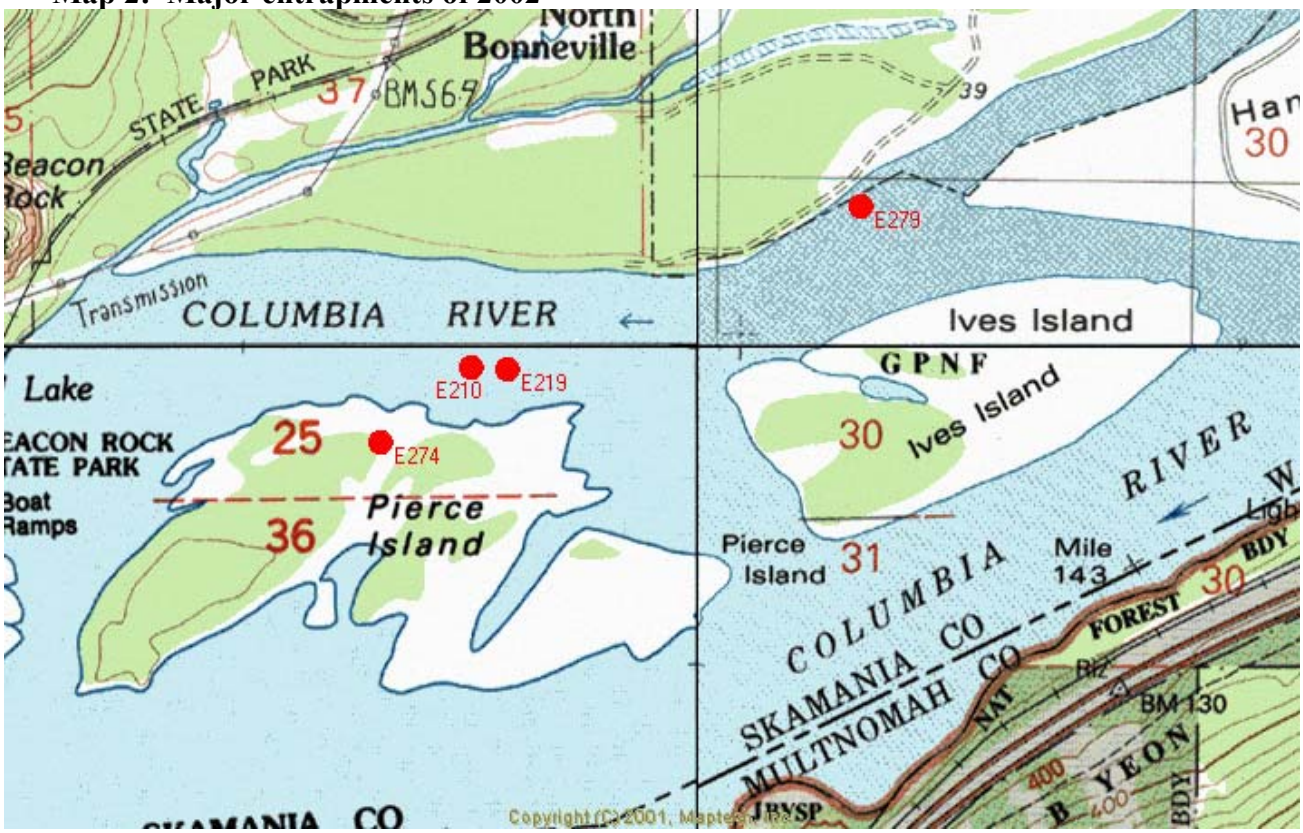


Table 3. Accumulated salmon counts and spatial distribution for entrapment sites containing the majority of sampled fish (includes fish found at stranding sites located within the perimeters of a dewatered entrapment). Numbers in parenthesis represent mortalities.

	Entrapment			
	E210	**E219**	**E274**	**E279**
Chum salmon	401	30(30)	0	6
Chinook salmon	291	21(21)	229	241
Coho salmon	176(1)	68(68)	52	77
Total salmon	868(1)	119(119)	281	324
% of total salmon sampled	38.20%	5.20%	12.40%	14.30%
River Mile	142.06	142.06	142.06	142.61
Latitude	N45 37. 462	N45 37.463	N45 37. 386	N45 37. 640
Longitude	W122 00. 453	W122 00.359	W122 00. 585	W121 59. 801
Sampling Area	**Area E**	**Area E**	**Area E**	**Area A**

Map 2: Major entrapments of 2002



The following are brief descriptions of each of the four major entrapments.

E210 (contained 38.2% of all sampled salmon) was a large shallow pond on the north shore of Pierce Island. It was near the center of an area of gently undulating topography and was influenced by Hamilton Channel (between Ives and Hamilton Island), Hamilton Creek, and the channel between Pierce and Ives Islands. In general, the surface of the river channel creating E210 was slightly higher than the surface of the main channel of the Columbia River.

E219 (5% of all sampled salmon, 34% of all mortalities) is within a cluster of five entrapments approximately 175 feet east of and slightly higher than E210. E219's substratum is almost entirely small and large pebble (16-64mm in diameter), which allows water to drain into the substrata fairly rapidly when the river level drops. The inability of E219 to maintain surface water for an extended period of time resulted in the largest die-ff of stranded juvenile salmon yet observed within the Ives/Pierce Islands study area. S217, the stranding location of 101 juvenile salmon mortalities, including 28 threatened chum, was within the drained area of E219. A review of Bonneville tailwater levels shows that it is likely the site still contained water two hours prior to the sampling visit at which time the sampling would have been of live entrapped salmon rather than stranded dead ones.

E279 (14.3% of all sampled salmon) was a deep pond on the Pierce Ranch N.W.R. immediately below the mouth of Hamilton Creek. Water remained cold and was not a threat to entrapped salmon.

E274 (12.4% of all sampled salmon) was a deep, straight channel cut through large cottonwoods on north central Pierce Island. Water flows into the entrapment from the north, and when high enough, exits to the south flowing through another entrapment and eventually into the lagoon on Pierce Island's south central shore.

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).

Tailwater levels at the times each of the three major entrapments were sampled are listed in Table 4. Return visits to each entrapment are identified by the entrapment code followed by –2, -3, -4, etc. In some cases, an entrapment's height above the river was remeasured during subsequent visits.

At the time of original sampling, each entrapment's height above the river was determined. 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. The heights above the river measurements for the four major entrapments are identified in Table 4. Theoretically, the height above the river could be used in conjunction with Bonneville tailwater measurements to determine critical tailwater levels for each entrapment. *Critical* tailwater levels refer to the Bonneville tailwater depths at which particular entrapments were formed. The unknown effects of river attenuation, tidal influences, and channel hydrology within the study area prevented us from identifying specific critical tailwater levels.

Table 4. Tailwater levels associated with the sampling of the four major entrapments. Return visits to an entrapment are identified by -2, -3, -4, etc.

ENTRAPMENT	SAMPLE DATE	SAMPLE TIME	HEIGHT ABOVE RIVER (ft)	TAILWATER LEVEL AT TIME OF SAMPLING (ft)	TAILWATER DEPTHS DURING THE 3 HOURS PRIOR TO SAMPLING (ft)
E210	2/4/2002	900	0.48	12.4	11.5-12.4
E210-2	2/18/2002	900	0.96	11.6	11.4-11.6
E210-3	3/24/2002	1100	NA	11.4	11.4-11.5
E210-4	3/27/2002	900	NA	13.3	11.7-13.3
E210-5	4/4/2002	1000	0.25	12.3	12.3-12.5
E210-6	4/8/2002	900	0.02	13.8	11.8-13.8
E219	2/6/2002	1100	0.81	14.6	14.0-14.7
E274	4/28/2002	1300	2.06	17.3	17.3-17.5
E274-2	5/7/2002	900	0.77	20.1	18.8-20.1
E274-3	5/15/2002	900	NA	17.4	17.1-17.4
E279	5/6/2002	800	1.17	17.1	16.7-17.1
E279-2	5/13/2002	1100	NA	17.5	15.5-17.5
E279-3	5/15/2002	800	NA	17.3	17.1-17.3
E279-4	5/20/2002	800	NA	18.5	17.4-18.5

5. Size Susceptibility

Mean, maximum, and minimum fork lengths for chum, chinook, and coho salmon are found in Tables B4, B5, and B6 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 5, along with the median fork length (intersections). The median fork length for entrapped chum salmon ranged from 43-45mm.

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 6, along with the median fork length (intersections). The median fork length for entrapped chinook salmon ranged from 38-54mm prior to June 9th and 65-89mm between June 9th and July 20th.

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 7, along with the median fork length (intersections). The median fork length for entrapped coho salmon was less than 40 mm through April 13th. A trend of increasing fork length can be seen for coho salmon entrapped during the month of May.

Figure 5. Minimum, maximum and median fork length of threatened chum salmon collected at entrapment sites near the Ives Island of the Columbia River in 2002. The lower and higher ends of the vertical lines represent the minimum and maximum fork length observed in the sample at the date, with the intersections as the median fork length.

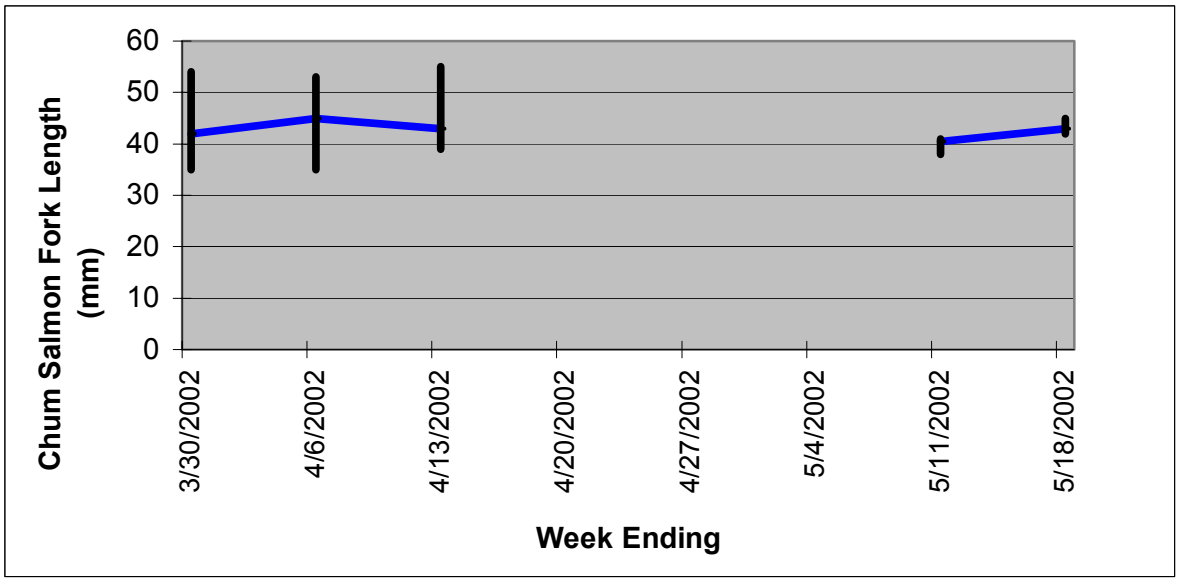


Figure 6. Minimum, maximum and median fork length of chinook salmon collected at entrapment sites near Ives Island of the Columbia River in 2002. The lower and higher ends of the lines represent the minimum and maximum fork length observed in the sample at the date, with the intersection as the median fork length.

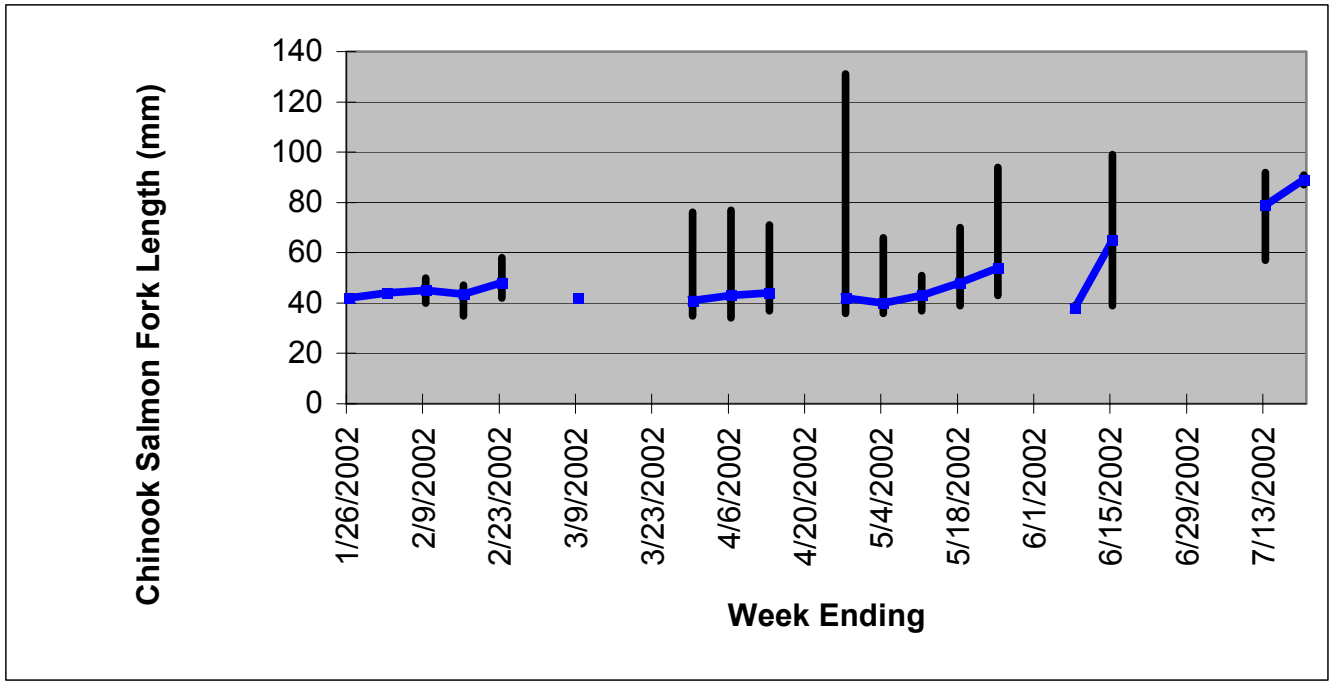
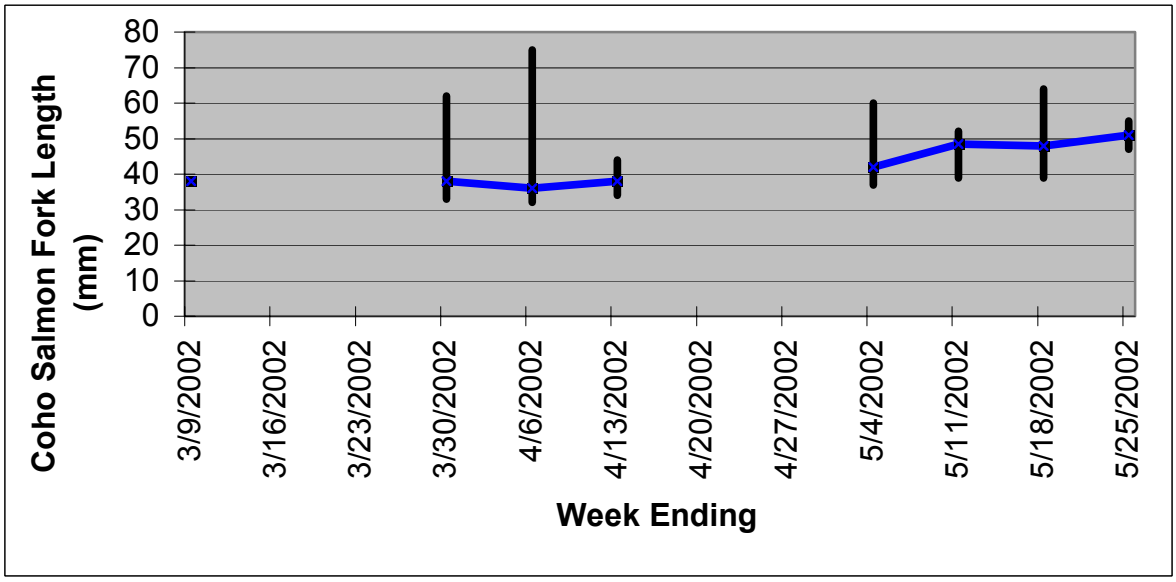


Figure 7. Minimum, maximum and median fork length of coho salmon collected at entrapment sites near the Ives Island of the Columbia River in 2002. The lower and higher ends of the lines represent the minimum and maximum fork length observed in the sample at the date, with the intersection as the median fork length.



Fork length summaries for stranded chum, chinook, and coho salmon are listed in Tables B7, B8, and B9 respectively. Stranded salmonids appear to have a size distribution similar to those of entrapped salmonids, with the majority of the fish having fork lengths from 40- 45 mm. The fork length tends to increase during the later portions of the sampling period for stranded chinook salmon.

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 for dominant substrate size of fines, fine gravel, medium gravel, coarse gravel, and small and large pebble (Codes 1, 3, 4, 5, 6, and 7). 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 8. Although large pebble (7) appears the most often and accounts for 31.3% of the chum entrapment sites, the substrate coarse gravel (5) was dominant at sites containing the majority of entrapped chum (66.2%) (Table B10).

The numbers of mortalities of entrapped chum salmon are also listed in Table B11. Most mortality (77.8%) occurred at sites with a dominant substrate of medium gravel (Code 4).

Stranded chum salmon (those found on dry land) were observed at sites with dominant substrate sizes of fines, coarse gravel, and small and large pebble (Codes 1, 5, 6, and 7). Small pebble (6) was the dominant substrate at sites containing 88.5% of all sampled stranded chum (Table B11).

Figure 8. Percentage of entrapment sites with a particular dominant substrate, and the percentage of entrapped chum salmon found at those sites.

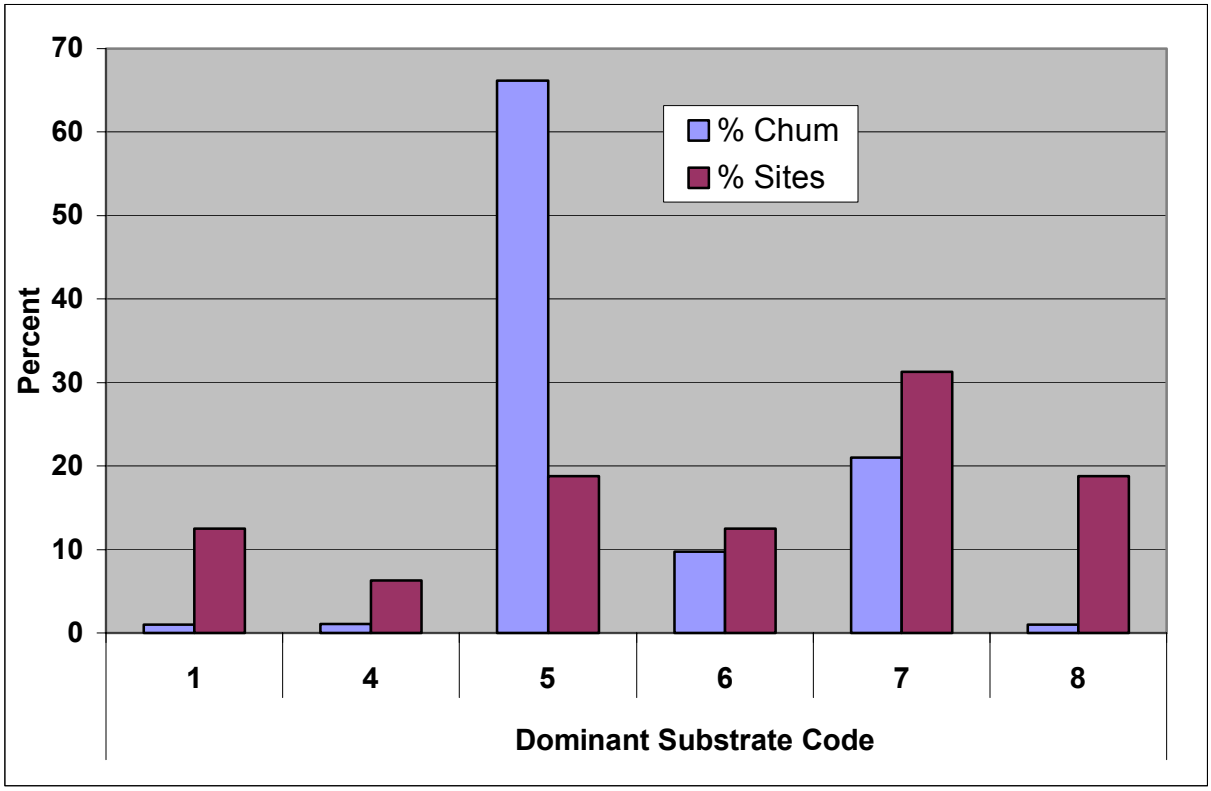
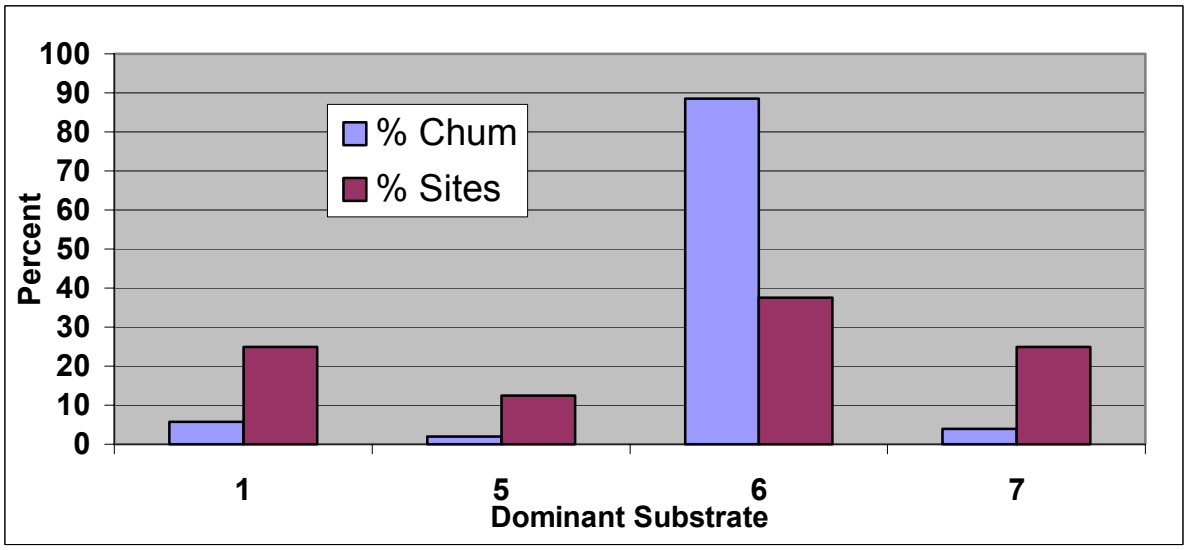


Figure 9. Percentage of stranding sites with a particular dominant substrate, and the percentage of stranded chum salmon found at those sites



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 percent of sites with a particular dominant substrate and the percentage of entrapped chinook salmon found on that substrate, are plotted in Figure 9. The dominant substrate fines (Code 1) appears most often and accounts for 33.3% of the chinook salmon entrapment sites. The largest numbers of entrapped chinook (36.3%) were observed at these sites (Figure 10 and Table B12).

The numbers of mortalities of entrapped chinook salmon were greatest (61.9%) 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 every size category except boulder (9). Small pebble (6) was the dominant substrate at sites containing 68.7% of all sampled stranded chinook (Table B13).

Figure 10. Percentage of <u>entrapment</u> sites with a particular dominant substrate, and the percentage of chinook salmon found on those sites.

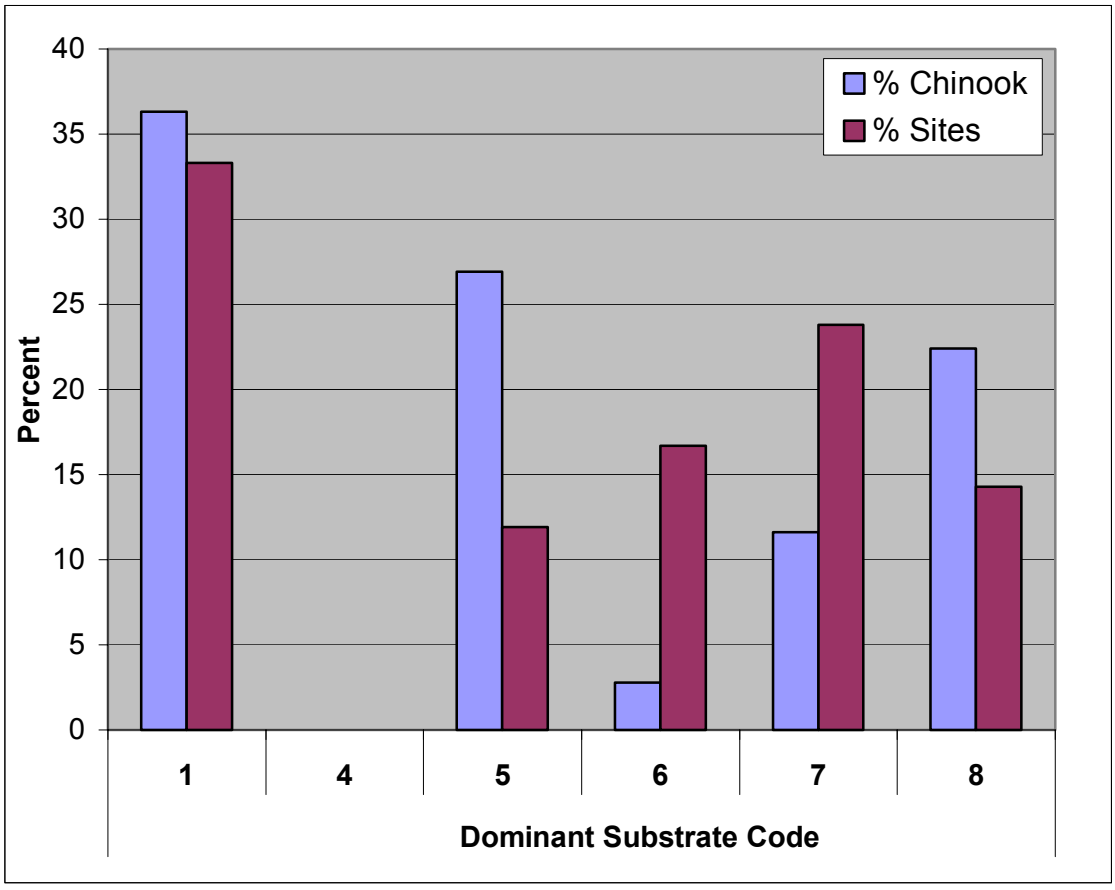
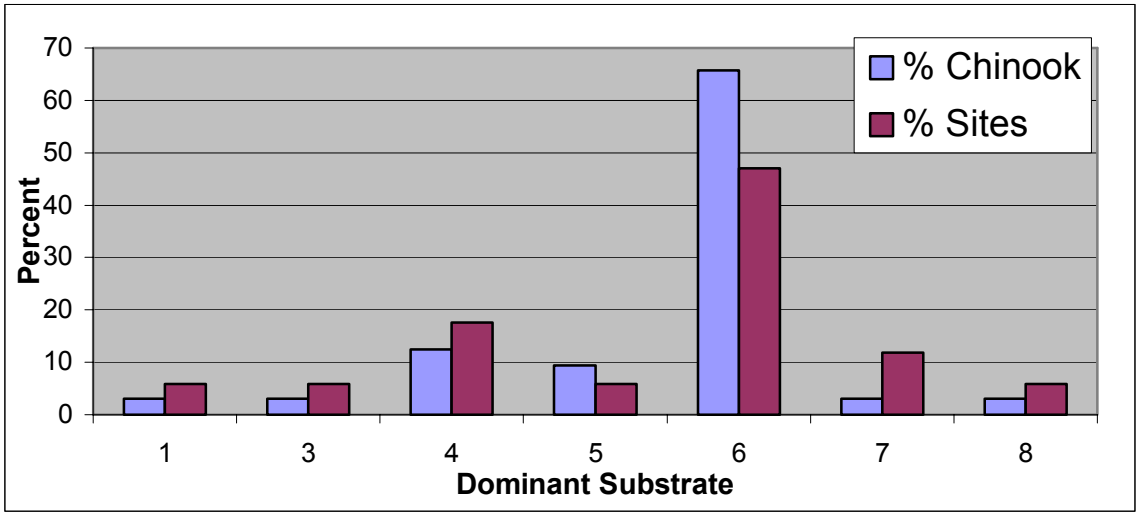


Figure 11. Percentage of <u>stranding</u> sites with a particular dominant substrate, and the percentage of chinook salmon found at those sites.



Entrapped coho salmon were observed for dominant substrate sizes of fines, small pebble, large pebble, and cobble (Codes 1, 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 11. The substrate fines (Code 1) appears most often, accounting for 42.1% of the sites. The substrate fines (Code 1) represents the dominant substrate for sites containing the majority of coho (55%) (Figure 11 and Table B14).

One <u>entrapped</u> coho salmon mortality was sampled; the dominant substrate at that site was fines (Code 1).

Stranded coho salmon (those found on dry land) were observed at sites with dominant substrates of medium gravel and small pebble (5 & 6). Small pebble was the dominant substrate at sites containing 97.6% of all sampled stranded coho (Table B15).

Figure 12. Percentage of <u>entrapment</u> sites with a particular dominant substrate, and the percentage of entrapped coho salmon found at those sites.

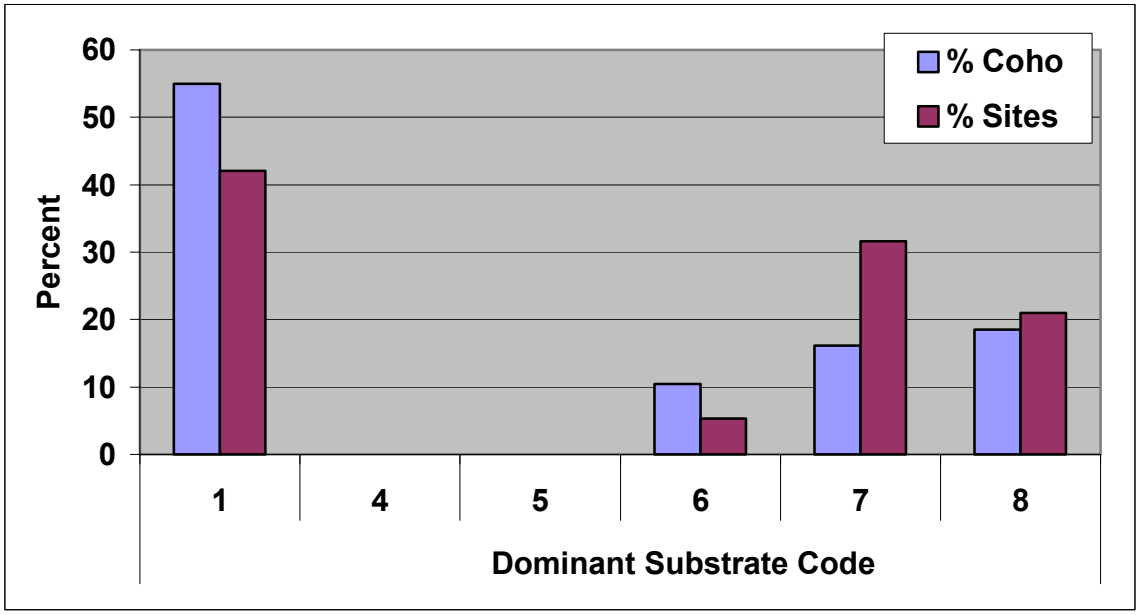
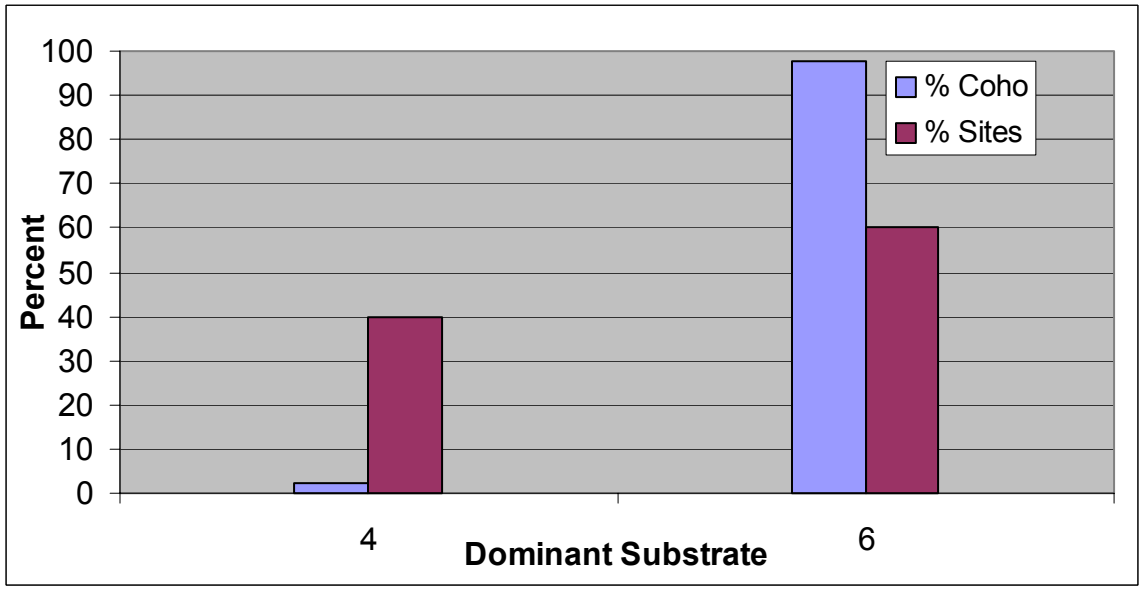


Figure 13. Percentage of <u>stranding</u> sites with a particular dominant substrate, and the percentage of stranded coho salmon found at those sites.



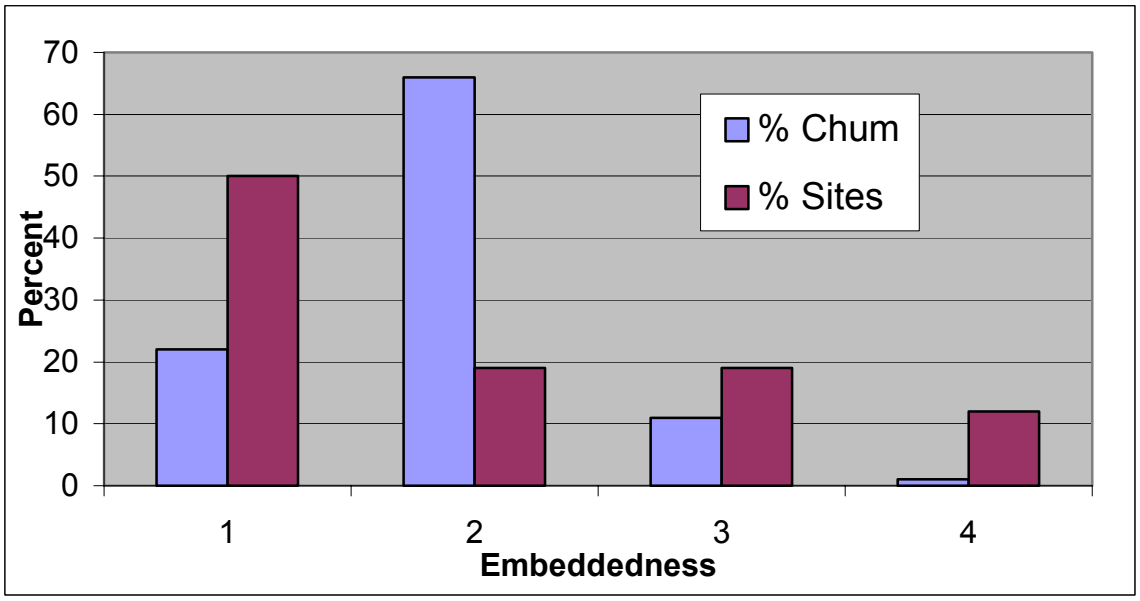
7. Substrate Embeddedness

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 (66.2%) were found at sites with substrate embeddedness of 25 to 50% fines (code 2, Figure 14). The highest mortality rate (10.6%) occurred at entrapment sites with substrate embeddedness of 50 to 75% fines (code 3, Table B16).

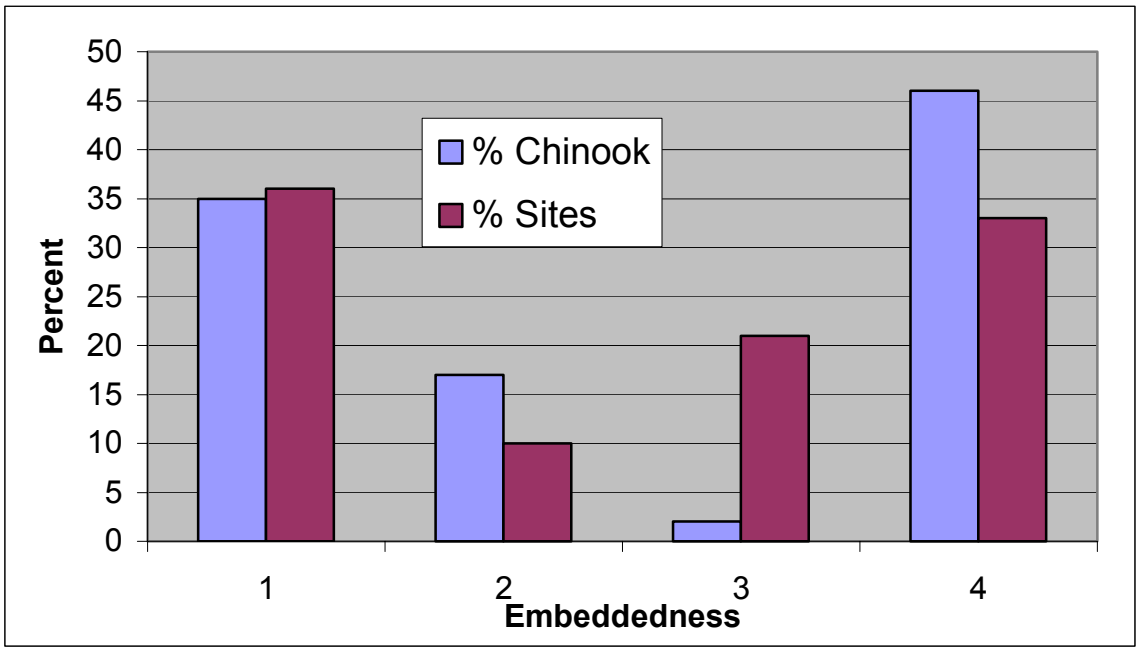
Figure 14: Degrees of substrate embeddedness at chum entrapment sites



The mean and median numbers of threatened chum salmon per survey site found an stranding sites with various degrees of substrate embeddedness are listed in the last two rows of Table B17. The majority of stranded chum salmon (69.2%) were found at sites with substrate embeddedness of 50 to 75% fines (code 3).

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 B18. The majority of entrapped chinook occurred in sites with substrate embeddedness of 0 to 25% (code 1) and sites with substrate embeddedness of 75 to 100% (code 4), 34.6% and 46.2%, respectively (Figure 15). The highest mortality rate (58.3%) was found in sites with substrate embeddedness of 50 to 75% (code 3).

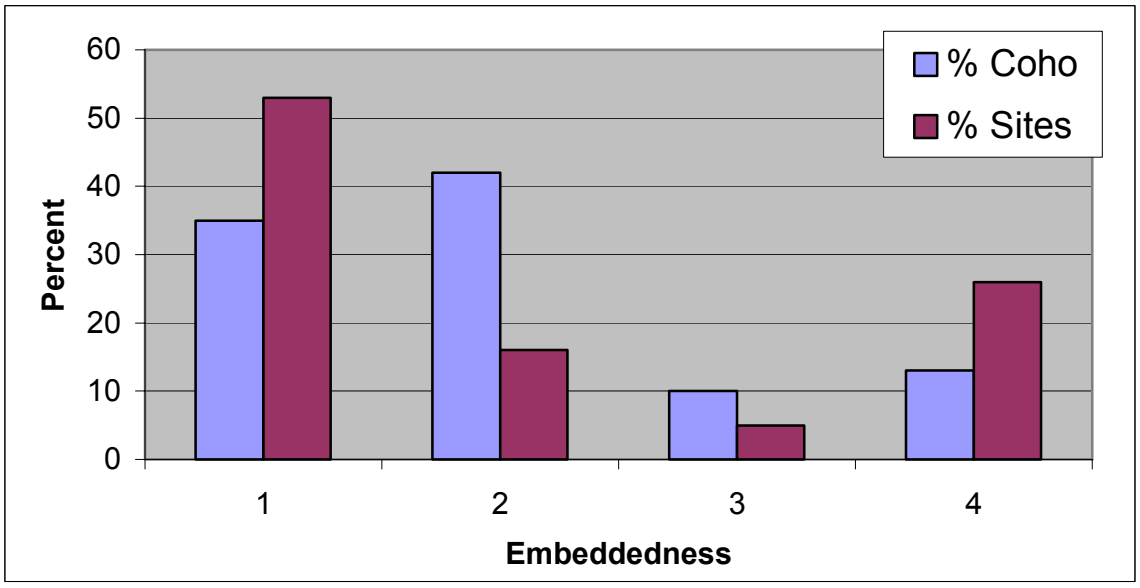
Figure 15: Degrees of substrate embeddedness at chinook entrapment sites



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 B19. The majority of stranded chinook (85.5%) occurred in sites with substrate embeddedness of 50 to 75% (code 3).

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 B20. The majority of entrapped coho were split between substrate embeddedness 0 to 25% (code 1) and substrate embeddedness 25 to 50% (code 2), 34.6% and 41.6% respectively (Figure 16). The only sampled coho mortality occurred at an entrapment site with a substrate embeddedness of 75 to 100%.

Figure 16: Degrees of substrate embeddedness at coho entrapment sites



The mean and median numbers of coho salmon per survey site found at stranding sites with various degrees of substrate embeddedness are listed in the last two rows of Table B21. The majority of stranded coho were sampled at sites with substrate embeddedness of 50 to 75% (code3).

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.

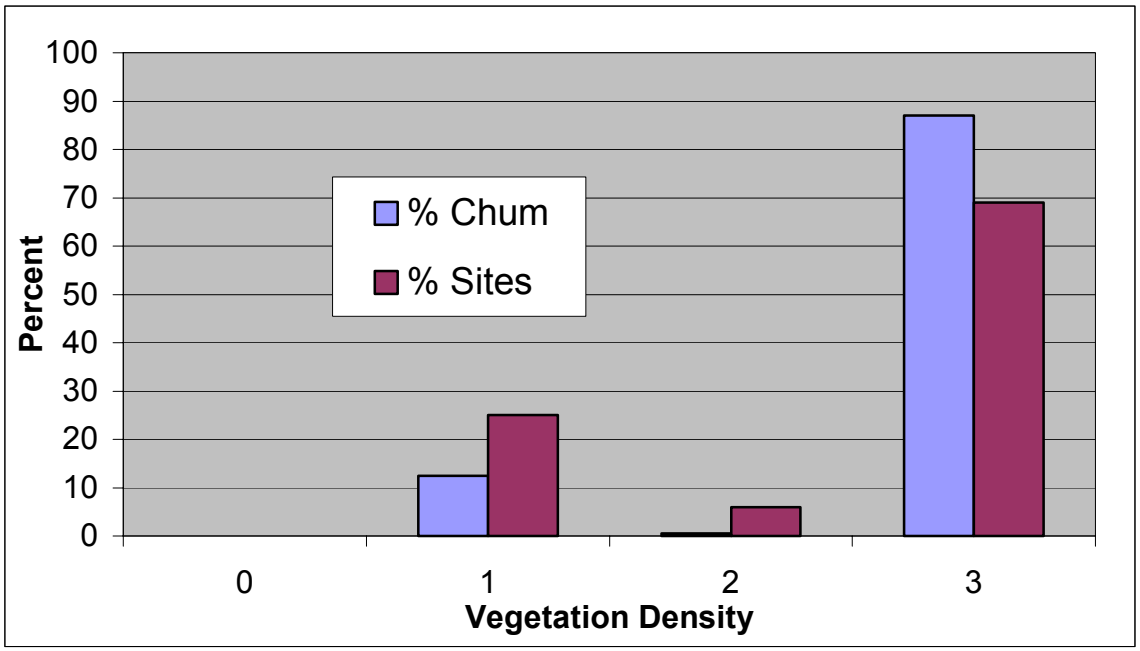
During the year 2002, entrapments with medium and dense vegetation contained primarily aquatic plants, including algae.

Chum, chinook, and coho salmon were all found in areas of all four vegetation densities although a total of only four salmon (2 chum, 1 chinook, and 1 coho) were found in entrapments void of vegetation.

The greatest numbers of entrapped chum salmon were found at sites with dense vegetation (code 3, Table B22). The majority of chum entrapment sites had dense

aquatic vegetation (Figure 17). The majority of chum mortalities occurred in areas of sparse vegetation.

Figure 17: Degrees of vegetation density within chum entrapments

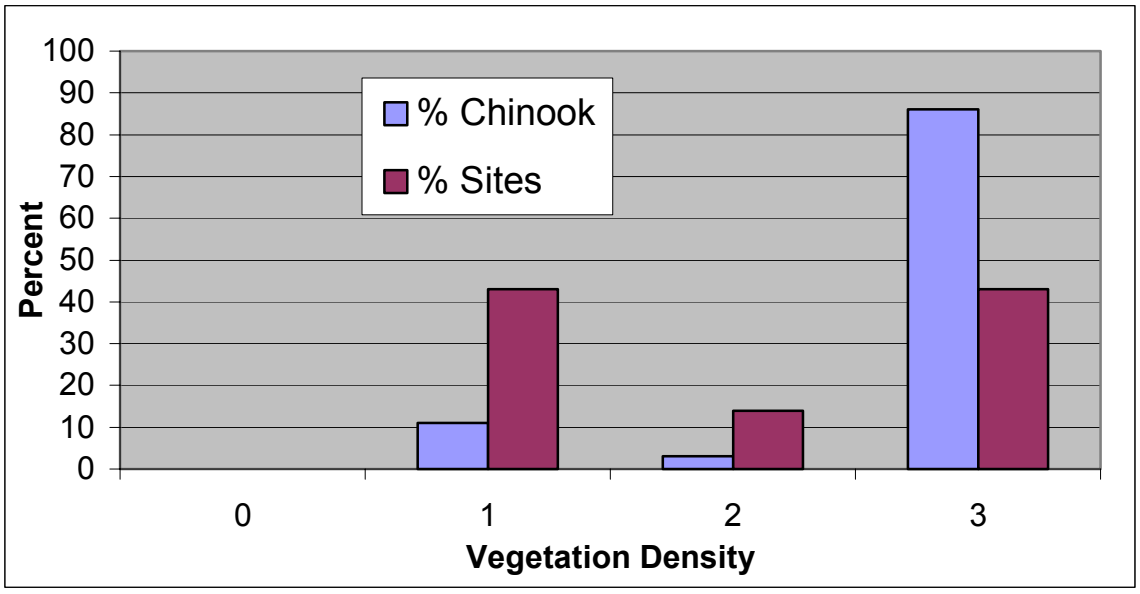


The greatest numbers of stranded (those found out of water) chum salmon (92.3%) were found in sites with sparse vegetation (code 1, Table B23).

Eighty-three percent of all chum discovered in areas of sparse vegetation were mortalities.

The greatest numbers of entrapped chinook salmon (83.7%) were found at sites with dense vegetation (code 3, Table B24). Equal numbers of chinook entrapment sites were found in areas of sparse and dense vegetation (codes 1 and 3, Figure 18).

Figure 18: Degrees of vegetation density within chinook entrapments

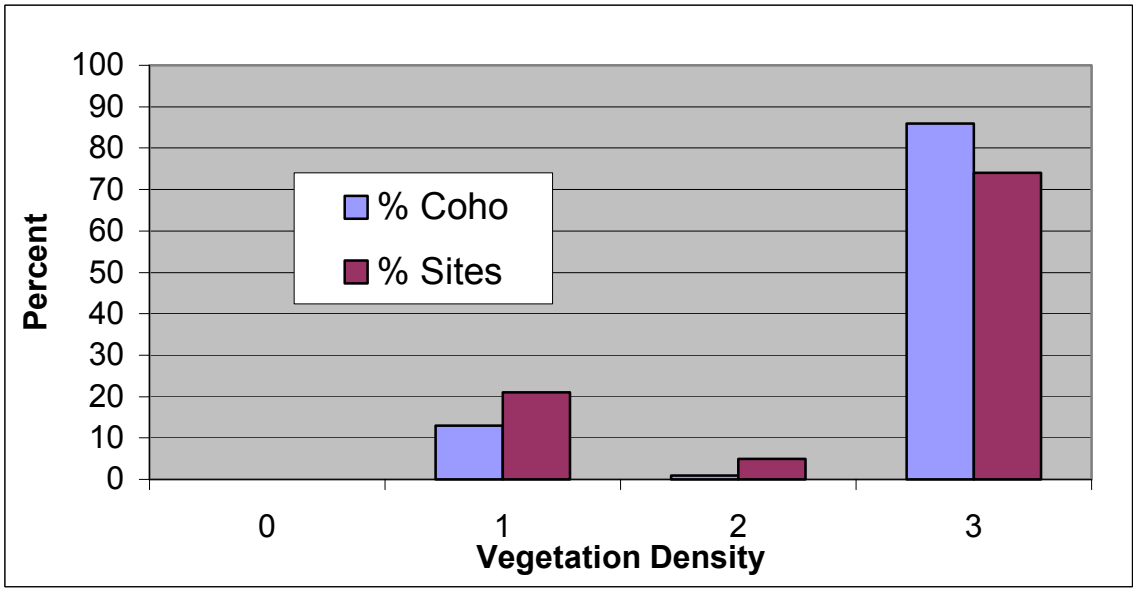


The greatest numbers of stranded chinook (88.2%) were found at sites with sparse vegetation (code 1, Table B25).

The greatest number of chinook mortalities (88.7%) occurred at sites with sparse vegetation (Table B24).

The greatest numbers of entrapped coho were found at sites with either sparse or dense vegetation (codes 2 and 3, Table B26). The greatest numbers of stranded coho (98.8%) were found at sites with sparse vegetation (code 1, Table B28).

Figure 19: Degrees of vegetation density within coho entrapments



The majority of coho mortalities (80%) were discovered in a single dewatered entrapment containing sparse vegetation.

9. Temperature

Two entrapment temperatures were taken, one at the beginning of the sampling event and one at the end. The beginning and ending temperatures were taken at the same location within the entrapment. 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 78°F and above are considered lethal to juvenile chum and coho salmon (Bell 1973). Water temperatures of 77°F and above are considered lethal to juvenile chinook salmon (Brett 1952). The highest known water temperature of any entrapment containing juvenile salmon was 67° F. It is possible that water temperatures exceeded the lethal thresholds at a time when samplers were not present but probably not in a situation that led to the death of a significant number of juvenile salmon. Of the 2071 sampled juvenile salmon found in entrapments, 31 (1.5%) were found dead, and of those, only 2 were found in water exceeding 60°F. For comparison, 168 (7.4% of all sampled salmon) were found dead at sites that had been dewatered.

The temperatures of entrapments known to contain any of the three species of juvenile salmon ranged from 33° F to 67° F. The temperature range of entrapments known to contain chum mortalities was 58° F to 66° F. The temperature range of entrapments known to contain chinook mortalities was 39.5° F to 51° F. The temperature of the entrapment with the known coho mortality was 46° F.

Seven hundred sixty juvenile salmon were found in entrapments with water temperatures in excess of 60° F. Of those fish, only 2 (00.26%) were mortalities.

Mortality of threatened chum salmon at the entrapment sites was plotted against the three temperature measurements (Figure 20). The measurements of air temperature and entrapment temperatures had a correlation coefficient of .8594. The measurements of entrapment temperature and river temperature had a correlation coefficient of .7107 (Table B28). The highest chum mortality at an entrapment was observed on March 31, the entrapment temperature was 58° F.

Mortality of threatened chinook salmon at the entrapment sites was plotted against the same temperature measurements as the chum (Figure 21). Air and entrapment temperatures had a correlation coefficient of .6622. River and entrapment temperatures had a correlation coefficient of .7680. Peak mortality was observed on February 6 in entrapments having temperatures of 39.5° F (Table B29).

Temperature data related to the lone coho mortality retrieved from an entrapment is found in Table B30. The mortality was sampled on March 27.

Figure 20. Mortality of threatened chum salmon and temperature measurements at entrapment sites near the Ives Island of the Columbia River in 2001.

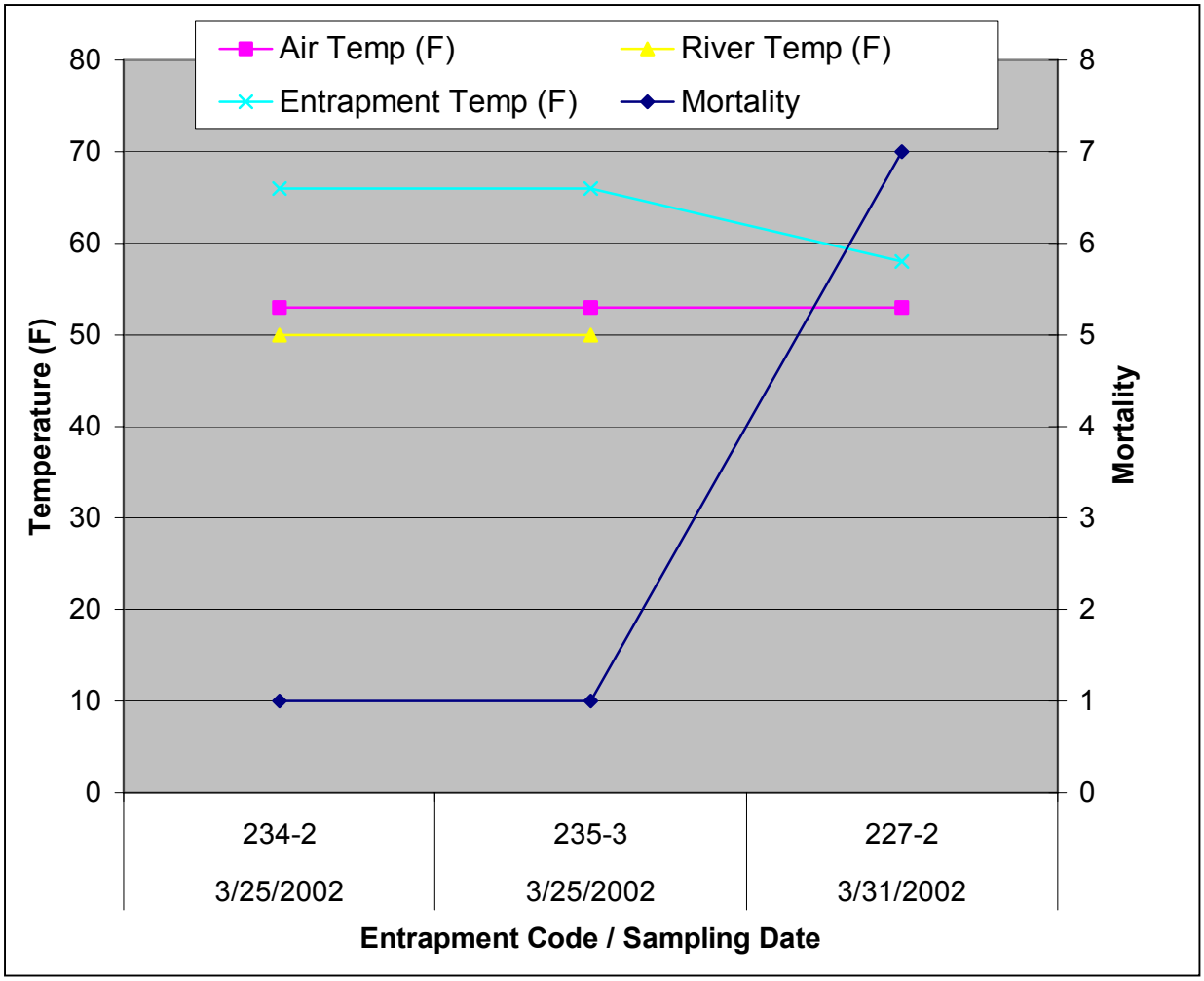
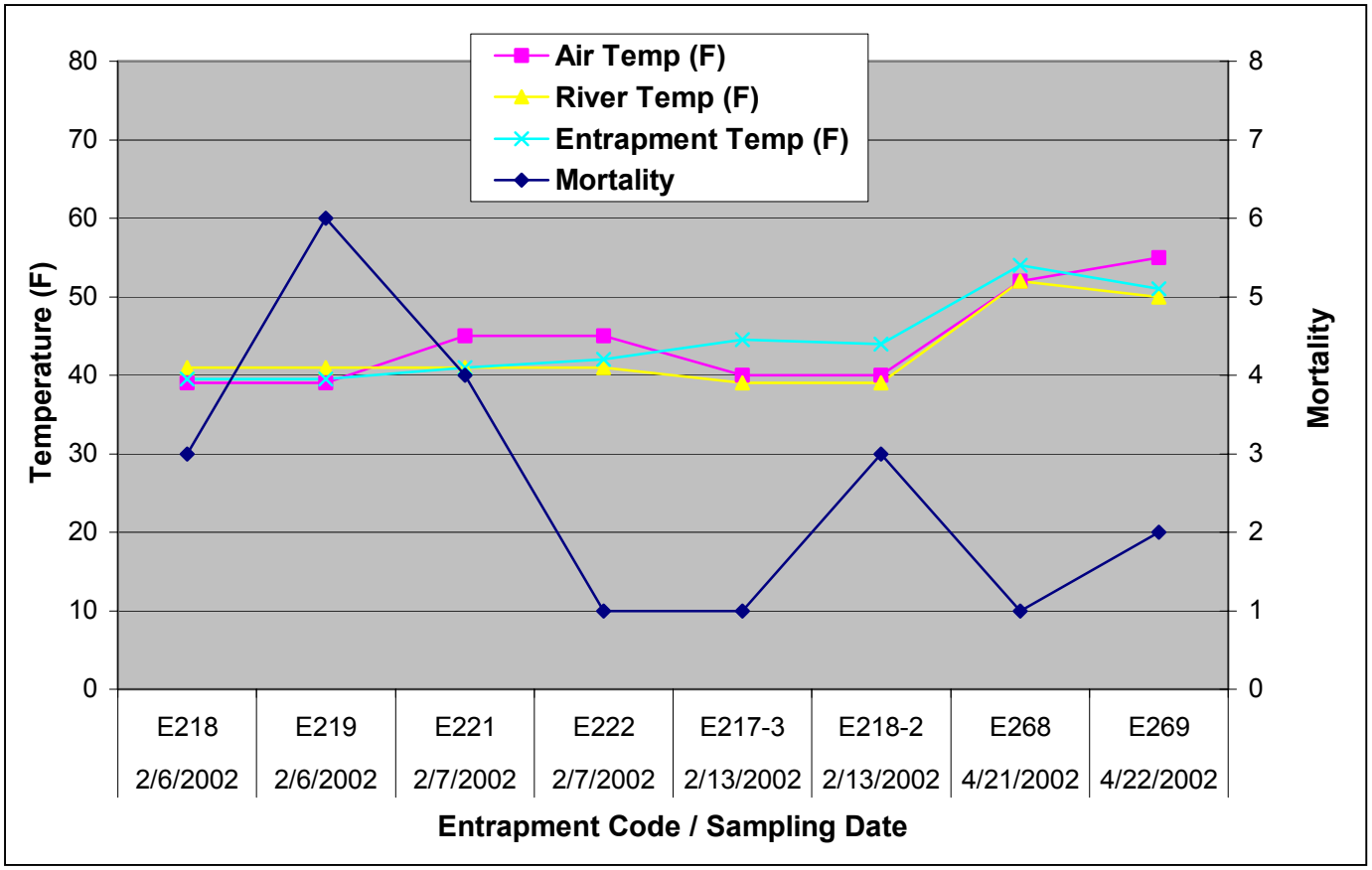


Figure 21. Mortality of chinook salmon and temperatures measurements at entrapment sites near Ives Island of the Columbia River in 2001



10. Year-to-Year Comparison

Table 5 shows a comparison of the number of fish sampled during each of the three study years. The table is followed by a discussion of each of seven major entrapments and possible reasons for the increase in the number of chum and coho seen in 2002.

Table 5. Sampling totals by study year

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

MAP 3: Major entrapments of 2000, 2001, and 2002.

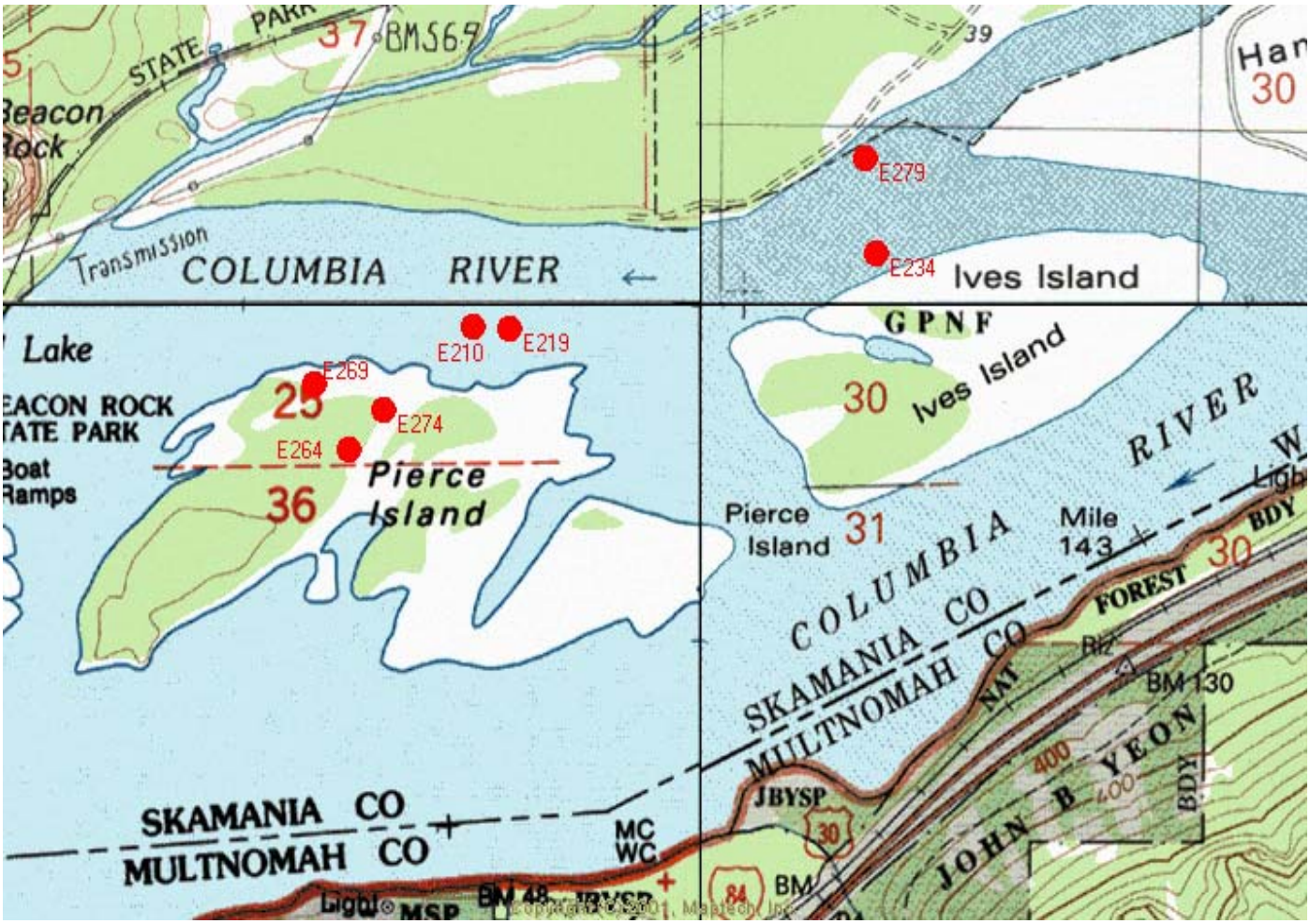


Table 6. Yearly sampling totals per major entrapment

Entrapment and Year	Live Chinook (% of all chin by year)	Live Chum (% of all chum by year)	Live Coho (% of all coho by year)	Dead Chin	Dead Chum	Dead Coho
E274 Pierce Is.						
2000	715 (54.5%)	3 (37.5%)	0	6	0	0
2001	Dry all season.	NA	NA	NA	NA	NA
2002	229 (20.6%)	0	52 (10.4%)	0	0	0
E210 Pierce Is.						
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%)	175 (35%)	0	0	1
E269 Pierce Is.						
2000	205 (15.6%)	0	0	0	0	0
2001	Dry all season.	NA	NA	NA	NA	NA
2002	122 (11.0%)	0	0	2	0	0
E219 Pierce Is.						
2000	Few or none	0	0	0	0	0
2001	0	0	0	0	0	0
2002	0	0	0	21	30	68
E264 Pierce Is.						
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
E234 Ives Is.						
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
E279 Pierce Ranch						
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

*In 2002,the sampling crew switched from a 30ft stick sein net to a 100ft beach sein net when sampling E279.

E210 contained 25.7% of all sampled salmon and 48.5% of all sampled chum during the 2000, 2001, and 2002 sampling periods.

E210 is a broad shallow pond forming N.E. of E274 and S.W. of E219 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 across E219 from the channel separating Ives and Pierce Islands. Although only small numbers of dead salmon have been documented within this entrapment, the possibility of high water temperatures due to E210's shallowness poses a serious threat to entrapped salmon on sunny days. E210 is part of a large area of undulating topography, which includes E219 and many other lesser entrapments. E210 has trapped more threatened chum than any other entrapment during the 2 years it has been sampled.

E219 contained only 2.8% of all sampled juvenile salmon and 2.7% of all sampled chum but it contained 34.8% of all juvenile salmon mortalities and 28.8% of all chum mortalities during the 2000, 2001, and 2002 sampling periods.

E219 is within a cluster of five entrapments approximately 175 feet east of E210. The entrapments are at a slightly higher elevation than E210 and water disappears into the substrata fairly rapidly when the river level drops. E219 was responsible for the largest die-off of stranded juvenile salmon yet discovered within the Ives/Pierce study area.

E234 contained 6.2% of all sampled juvenile salmon and 14.8% of all sampled chum during the 2000, 2001, and 2002 sampling periods.

E234 is 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 E234 but blocked by a broad low-lying berm. In some cases, subsurface flow, probably coming from Hamilton Channel, replenished water within E234 without allowing entrapped salmon an opportunity to escape.

E264 contained 4.1% of all sampled juvenile salmon and 0% of all sampled chum during the 2000, 2001, and 2002 sampling periods.

E264 is near the middle of Pierce Island just southwest of E274. It receives water from the north via E274 and expels water to the south. The southern border of E264 is formed by what looks like an old roadbed. If the roadbed were removed, most of E264's water would drain into another entrapment to the south.

E269 contained 6.3% of all sampled juvenile salmon and 0% of all sampled chum during the 2000, 2001, and 2002 sampling periods.

E269 is an isolated clearing west of E274 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.

E274 contained 19.1% of all sampled juvenile salmon and 4.7% of all sampled chum during the 2000, 2001, and 2002 sampling periods.

E274 is 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 E264 and eventually into the lagoon in Pierce Island's south central shore. E274 has the appearance of a man made channel. A berm of natural deposits has formed at its' north entrance. Cutting water flow through E-1 would reduce the likely-hood of E264 becoming an entrapment.

E279 contained 6.0% of all sampled juvenile salmon and 0.5% of all sampled chum during the 2000, 2001, and 2002 sampling periods.

E279 is a deep depression on the Pierce Ranch N. W. R. immediately below the mouth of Hamilton Creek.

A greater number of threatened chum salmon and coho salmon were found entrapped or stranded in 2002 than in either of the previous two sample years. The reason for the increase is unclear but, especially in the case of chum, appears to be related to entrapment E210.

In 2001, E210 was known to contain a total of 136 chum, in 2002, it was known to contain a total of 401 chum, and in 2000, low river levels prevented E210 from filling. More juvenile chum were sampled from E210 in a single day in 2002 (254 on April 4) than in all of 2001. In fact, the difference in the total number of entrapped or stranded chum within the entire study area (217 more in 2002) might be accounted for by a single day of sampling at E210.

Why were more chum entrapped by E210 in 2002 than in 2001? It is difficult to say. The general topography of the area appeared to be unchanged and the size of the entrapment also seemed about the same. The dates the entrapment was sampled were also similar for the two years, 3/29, 4/2, 4/6, 4/13, and 5/10 in 2001, and 3/27, 4/4, and 4/8 in 2002.

The two biggest differences were river levels and likely population sizes. The peak chum redd count during the fall of 2001 (181 on 11/26) was nearly twice as great as the peak redd count during the fall of 2000 (95 on 12/01) which probably signifies a larger emerging population in 2002. There are, however, factors that cloud the certainty of that assumption. Various physical conditions can affect emergence success. Some flow rates can wash away gravel and eggs or, conversely, bury the eggs under fine sediment. Extremely low flows can dewater some redds. Physical conditions such as turbidity,

waves and rain can make spotting redds more difficult during one year than during another.

In addition, it takes more than high emergence numbers for salmon to become entrapped; they also must remain in the vicinity of potential entrapments. Looking at the Ives Island juvenile surveys conducted at the same time as entrapment surveys is one way to gain some insight into how many juvenile chum were in the near-shore area at the time E210 was being sampled. Between 3/25 and 4/15, the period of time E210 was sampled most frequently, 1,763 chum were netted by the juvenile survey team in 2001 and 387 were netted in 2002 (van der Nald, 2002)(ODFW, 2003), the exact opposite of what would be expected from the previous falls' redd counts. It should be noted that river conditions that affect the success of the seining were not the same during each of the two years and that lower river levels made it easier to net fish in 2001.

Tailwater levels were similar whenever E210 was sampled each year, however they were distinctly different between samplings. Between 3/25 and 4/15 the range of tailwater levels was 6.6 to 15.3 feet in 2001 and 11.2 to 24.2 feet in 2002 (Army Corps of Engineers). Although river attenuation and local channel hydraulics make pinpointing a specific critical tailwater level (the point at which E210 forms) all but impossible, it appears to be within a range of 12 to 13 feet (Table 4). In other words, E210 was being sampled when water levels were relatively low in 2002 but relatively high in 2001. Juvenile chum had a much greater opportunity and perhaps a greater need to reside within the entrapment area in 2002 than they did in 2001, which might be why more were sampled in 2002.

11. Summary

During the 2002 sampling period near Ives Island on the Columbia River, 49% of the 2,272 sampled fish were chinook salmon, 29% were threatened chum salmon, and 22% were coho salmon. 170 salmon were observed stranded (dewatered) of which 34 were chinook, 52 were chum, and 84 were coho.

Mortality and stranding rates were highest for coho salmon, 17% and 16.8% respectively. Mortality and stranding rates for sampled chum salmon were 9.3% and 7.9%, respectively. Mortality and stranding rates for chinook salmon were 4.8% and 3.1% respectively. Two of the stranded salmon, both chinook, were still alive when sampled.

Peak numbers of threatened chum salmon were observed between March 24 and April 13, primarily along the northern and southern shores of Pierce Island and, to a lesser degree, along the northwestern shore of Ives Island (Areas E, D, and A, Map 1). The greatest numbers of chum salmon mortalities (60.9%) were observed along the northern shore of Pierce Island (Area E, Map 1).

Peak numbers of threatened tule chinook salmon were observed between February 3 and February 23. Peak numbers of upriver bright chinooks were observed between March 24

and May 25. The majority of sampled chinook salmon were observed along the northern and southern shores of Pierce Island (Areas E and D, Map 1). The greatest numbers of chinook salmon mortalities (98.8%) were observed along the northern shore of Pierce Island (Areas E, Map 1).

Peak numbers of coho salmon were observed between March 24 and May 18, primarily along the northern and southern shores of Pierce Island (Areas E and D, Map 1). The greatest numbers of coho salmon mortalities (60.9%) were observed along the northern shore of Pierce Island (Area E, Map 1).

Tailwater levels ranged between 11.2ft and 24.2ft (Army Corps of Engineers) during the sampling of the four major entrapments. The unknown affects of river attenuation, tidal variation, and channel geometry within the study area prevent the identification of specific critical tailwater levels associated with formation of the entrapments.

The fork length data indicate that the majority of the entrapped and stranded salmon are in the 40-50 mm range. Longer fork lengths are seen later in the season, especially for chinook salmon, however, the number of fish entrapped or stranded later in the season is lower than earlier in the season when the fish are smaller. This appears to agree with the conclusions of Nugent et al. that show that salmonids are most likely to be impacted by river level fluctuations when they are small, soon after emergence.

Two dominant substrates, coarse gravel and large gravel (codes 5 and 7), appear most often for entrapments containing chum salmon. Three substrate types, fines, small pebbles, and large pebbles (codes 1, 6, and 7), appeared most often for entrapments containing chinook salmon. The dominant substrates fines and large pebbles (codes 1 and 7) appear most often for entrapment sites containing coho salmon. The largest numbers of stranded chum, chinook, and coho salmon were all found at sites with a dominant substrate consisting of small pebbles (code 6).

Vegetation densities greater than sparse (code 1) were the result of aquatic plants, including algae. The greatest numbers of chum and chinook salmon were found in entrapments with dense aquatic vegetation (code 3). Most coho salmon were found at sites with either sparse (code 1) or dense (code 3) vegetation. The largest numbers of chum, chinook, and coho salmon mortalities were found at stranding sites with sparse vegetation.

Temperature did not appear to have a significant impact on salmon in the Ives Island Area. The temperatures of entrapments known to contain juvenile salmon ranged from 33° F to 67° F, much lower than the 77º F to 78º F temperatures published as lethal limits for salmonids. The temperature range of entrapments known to contain chum mortalities was 58° F to 66° F. The temperature range of entrapments known to contain chinook mortalities was 39.5° F to 51° F. The temperature of the entrapment with the known coho mortality was 46° F. Seven hundred sixty juvenile salmon were found in entrapments with water temperatures in excess of 60° F. Of those fish, only 2 (00.26%) were mortalities.

All live sampled salmon were released into the Columbia River, so it is not known how many would have died if they had been returned to the entrapments.

A greater number of threatened chum salmon and coho salmon were found entrapped or stranded in 2002 than in either of the previous two sample years. The reason for the increase is unclear but, especially in the case of chum, appears to be related to entrapment E210. More juvenile chum were sampled from E210 in a single day in 2002 (254 on April 4) than in all of 2001. In fact, the difference in the total number of entrapped or stranded chum within the entire study area (217 more in 2002) might be accounted for by a single day of sampling at E210. It is difficult to determine the exact cause for the increase in entrapment levels at E210, but the biggest differences between 2001 and 2002 were river levels, and possibly population sizes. The peak chum redd count during the fall of 2001 (181 on 11/26) was nearly twice as great as the peak redd count during the fall of 2000 (95 on 12/01) which probably signifies a larger emerging population in 2002. Tailwater levels were similar whenever E210 was sampled each year, however they were distinctly different between samplings. Between 3/25 and 4/15 the range of tailwater levels was 6.6 to 15.3 feet in 2001 and 11.2 to 24.2 feet in 2002 (Army Corps of Engineers). So, it appears that E210 was being sampled when water levels were relatively low in 2002 but relatively high in 2001. Juvenile chum had a much greater opportunity and perhaps a greater need to reside within the entrapment area in 2002 than they did in 2001, which might be why more were sampled in 2002.

Several factors create the likelihood that salmon mortalities were higher than recorded. Because of the size of the survey area, some juvenile salmon are likely to have been overlooked. Rising water levels may have swept away dead salmon prior to the arrival of samplers. Predators taking advantage of the confined waters or scavengers may have eaten some of the entrapped or stranded salmon.

References

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

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

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, 1999-2003. *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.

Appendix A: Site Coordinates

TABLE A. Year 2002 entrapment locations found near Ives Island on the Columbia River.

Entrapment Locations				Sampling
Entrapment Code	Species Sampled	Latitude	Longitude	Area
E201		N45 37.556	W121 59.786	A
E202		N45 37.557	W121 59.781	A
E203		N45 37.563	W121 59.763	A
E204	Chinook	N45 37.564	W121 59.743	A
E205	Chinook	N45 37.562	W121 59.850	A
E206		N45 37.569	W121 59.778	A
E207		N45 37.310	W122 00.278	C
E208		N45 37.236	W122 00.351	C
E209		N45 37.470	W122 00.255	E
E210	Chin, Coho	N45 37.462	W122 00.453	E
E211		N45 37.089	W122 00.537	D
E212		N45 37.087	W122 00.551	D
E213		N45 37.263	W122 00.025	B
E214		N45 37.267	W122 00.064	B
E215	Chinook	N45 37.557	W121 59.770	A
E216		N45 37.469	W122 00.400	E
E217	Chum, Chinook	N45 37.463	W122 00.393	E
E218	Chinook	N45 37.468	W122 00.376	E
E219	Chinook	N45 37.463	W122 00.359	E
E220		N45 37.451	W122 00.390	E
E221	Chinook	N45 37.437	W122 00.536	E
E222	Chinook	N45 37.443	W122 00.609	E
E223		N45 37.480	W122 00.483	E
E224		N45 37.483	W122 00.467	E
E225		N45 37.438	W122 00.456	E
E226	Chinook	N45 37.463	W122 00.291	E
E227	Chum	N45 37.467	W122 00.274	E
E228		N45 37.553	W121 59.686	A
E229	Chinook	N45 37.556	W121 59.660	A
E230		N45 37.617	W121 59.660	A
E231		N45 37.138	W122 00.191	B

E232	Chinook	N45 37.475	W122 00.521	E
E233		N45 37.491	W122 00.571	E
E234	Chinook, Coho	N45 37.534	W121 59.781	A
E235	Chum, Chinook	N45 37.545	W121 59.545	A
E236	Chinook, Coho	N45 37.545	W121 59.753	A
E237		N45 37.520	W121 59.793	A
E238		N 45 37.520	W121 59.824	A
E239		N45 37.269	W122 00.044	B
E240		N45 37.270	W122 00.034	B
E241		N45 37.237	W121 59.984	B
E242		N45 37.069	W122 00.531	C
E243		N45 37.559	W121 59.760	A
E244		N45 37.573	W121 59.721	A
E245		N45 37.616	W121 59.701	A
E246		N45 37.471	W122 00.251	E
E247		N45 37.448	W121 59.244	East Ives
E248		N45 36.883	W122 01.735	F
E249		N45 37.574	W121 59.811	A
E250		N45 37.583	W121 59.783	A
E251		N45 37.583	W121 59.756	A
E252		N45 37.591	W121 59.764	A
E253		N45 37.564	W121 59.816	A
E254		N45 37.543	W121 59.237	G
E255		N45 37.560	W121 59.276	G
E256		N45 37.557	W121 59.246	G
E257		N45 37.552	W121 59.235	G
E258	Chum	N45 37.494	W122 00.567	E
E259		N45 36.891	W122 01.738	F
E260		N45 37.438	W122 00.586	E
E261		N45 37.240	W122 00.000	B
E262		N45 37.242	W121 59.990	B
E263		N45 37.239	W122 00.017	B
E264	Chum, Chin, Coho	N45 37.317	W122 00.641	D
E265		Missing	Missing	D
E266		N45 37.620	W121 59.912	A
E267		N45 37.610	W121 59.921	A
E268	Chum, Coho	N45 37.620	W121 59.918	A
E269	Chum, Chin, Coho	N45 37.385	W122 00.727	E

E270		N45 37.326	W122 00.609	D
E271		N45 37.325	W122 00.572	D
E272		N45 37.338	W122 00.542	E
E273		N45 37.291	W122 00.645	D
E274	Chum, Chin, Coho	N45 37.386	W122 00.585	E
E275	Chum, Chin, Coho	N45 37.145	W122 00.441	C
E276		N45 36.876	W122 01.795	F
E277		N45 37.248	W122 00.059	B
E278		N45 37.255	W122 00.076	B
E279	Chum, Chin, Coho	N45 37.640	W121 59.801	A

TABLE B. Year 2001 stranding locations found near Ives Island on the Columbia River.

Stranding Locations				Sampling
Entrapment Code	**Species Sampled**	**Latitude**	**Longitude**	**Area**
S201	Chinook	N 45 37.468	W122 00.275	E
S202	Chinook	N45 37.444	W122 00.315	E
S203	Chinook	N45 37.448	W122 00.322	E
S204	Chum, Coho	N45 37.558	W121 59.777	A
S205	Chum, Chinook	N45 37.463	W122 00.359	E
S206	Coho	N45 37.451	W122 00.390	E
S207	Chum, Coho	N45 37.463	W122 00.393	E
S208	Coho	N45 37.463	W122 00.359	E
S209	Chum, Coho	N45 37.463	W122 00.359	E
S210	Chum, Coho	N45 37.468	W122 00.375	E
S211	Coho	N45 37.498	W122 00.513	E
S212	Coho	N45 37.490	W122 00.328	E
S213	Chinook	N45 37.467	W122 00.274	E
S214	Chum	N45 37.464	W122 00.316	E
S215	Chum, Coho	N45 37.451	W122 00.390	E
S216	Chum, Chin, Coho	Missing	Missing	E
S217	Chum, Chin, Coho	N45 37.463	W122 00.359	E
S218	Chum	N45 37.557	W121 59.770	A
S219	Chinook	N45 37.659	W121 59.841	A
S220	Chum, Chin	N45 37.673	W121 59.795	A
S221	Chinook	N45 37.610	W121 59.921	A
S222	Chinook	Missing	Missing	A

Appendix B: Tables

Table B1: Weekly sampling results of threatened chum salmon

Week	Stranded		Entrapped		Total Mortalities (Stranded + Entrapped)	Total Chum
	Mortality	Alive	Mortality	Alive		
March 10-16	1	0	0	0	1	1
March 17-23	0	0	0	0	0	0
March 24-30	0	0	2	121	2	123
March 31-April 6	48	0	7	323	55	378
April 7-13	0	0	0	147	0	147
April 14-20	0	0	0	0	0	0
April 21-27	3	0	0	0	3	3
April 28-May 4	0	0	0	0	0	0
May 5-11	0	0	0	4	0	4
May 12-18	0	0	0	2	0	2
Total	**52**	**0**	**9**	**597**	**61**	**658**

Table B2. Results of weekly sampling of chinook salmon

Week	Stranded		Entrapped		Total Mortalities (Stranded + Entrapped)	Total Chinook
	Mortality	Alive	Mortality	Alive		
January 20-26	0	0	0	2	0	2
January 27-February 2	0	0	0	1	0	1
February 3-9	4	0	14	59	18	77
February 10-16	4	2	4	2	8	12
February 17-23	9	0	0	20	9	29
February 24-March 2	0	0	0	0	0	0
March 3-9	4	0	0	3	4	7
March 10-16	1	0	0	0	1	1
March 17-23	0	0	0	0	0	0
March 24-30	1	0	0	209	1	210
March 31-April 6	6	0	0	68	6	74
April 7-13	0	0	0	65	0	65
April 14-20	0	0	0	0	0	0
April 21-27	1	0	3	57	4	61
April 28-May 4	0	0	0	189	0	189
May 5-11	0	0	0	46	0	46
May 12-18	0	0	0	191	0	191
May 19-25	0	0	0	21	0	21
May 26-June 1	1	0	0	0	1	1
June 2-8	0	0	0	3	0	3
June 9-15	0	0	0	90	0	90
June 16-22	0	0	0	0	0	0
June 23-29	1	0	0	0	1	1
June 30-July 6	0	0	0	0	0	0
July 7-13	0	0	0	31	0	31

July 14-20	0	0	0	2	0	2
Total	**32**	**2**	**21**	**1059**	**53**	**1114**

Table B3. Results of weekly sampling of coho salmon

Week	Stranded		Entrapped		Total Mortalities (Stranded + Entrapped)	Total Coho
	Mortality	Alive	Mortality	Alive		
March 3-9	0	0	0	3	0	3
March 10-16	0	0	0	0	0	0
March 17-23	0	0	0	0	0	0
March 24-30	1	0	1	98	2	100
March 31-April 6	82	0	0	135	82	217
April 7-13	0	0	0	50	0	50
April 14-20	0	0	0	0	0	0
April 21-27	1	0	0	0	1	1
April 28-May 4	0	0	0	43	0	43
May 5-11	0	0	0	20	0	20
May 12-18	0	0	0	64	0	64
May 19-25	0	0	0	2	0	2
Total	**84**	**0**	**1**	**415**	**85**	**500**

Table B4. Fork length summary of entrapped chum salmon

Week Ending	Number of Chum	Fork Length (mm)			
		Median	Mean	Minimum	Maximum
3/30/2002	123	42	41.2	35	54
4/6/2002	330	45	42.3	35	53
4/13/2002	147	43	46.2	39	55
4/20/2002	0				
4/27/2002	0				
5/4/2002	0				
5/11/2002	4	40.5	40	38	41
5/18/2002	2	43	43.5	42	45

Table B5. Fork Length summary of entrapped chinook salmon.

Week Ending	Number of Chinook	Fork Length (mm)			
		Median	Mean	Minimum	Maximum
1/26/2002	2	42	42	42	42
2/2/2002	1	44	44	44	44
2/9/2002	73	45	44.6	40	50
2/16/2002	6	43.5	41.6	35	47
2/23/2002	20	48	48	42	58
3/2/2002	0				
3/9/2002	3	42	42	42	42
3/16/2002	0				
3/23/2002	0				
3/30/2002	209	41	42.5	35	76
4/6/2002	68	43	44.8	34	77
4/13/2002	65	44	45.4	37	71
4/20/2002	0				
4/27/2002	60	42	45.8	36	131
5/4/2002	189	40	41.3	36	66
5/11/2002	46	43	43.1	37	51
5/18/2002	191	48	48.2	39	70
5/25/2002	21	54	55.1	43	94
6/1/2002	0				
6/8/2002	3	38	38.3	38	39
6/15/2002	90	65	63	39	99
6/22/2002	0				
6/29/2002	0				
7/6/2002	0				
7/13/2002	31	79	75.7	57	92
7/20/2002	2	89	89	87	91

Table B6. Fork Length summary of entrapped coho salmon

Week Ending	Number of Coho	Fork Length (mm)			
		Median	Mean	Minimum	Maximum
3/9/2002	3	38	38	38	38
3/16/2002	0				
3/23/2002	0				
3/30/2002	99	38	38.4	33	62
4/6/2002	135	36	37	32	75
4/13/2002	50	38	37.8	34	44
4/20/2002	0				
4/27/2002	0				
5/4/2002	43	42	43.2	37	60
5/11/2002	20	48.5	46.8	39	52
5/18/2002	64	48	47	39	64
5/25/2002	2	51	51	47	55

Table B7. Observed fork length summary of threatened chum salmon at stranding sites near Ives Island in 2002.

Date	Number of Chum	Fork Length (mm)		
		Mean	Minimum	Maximum
3/10/02	1	39	39	39
4/3/02	48	41.5	38	48
4/25/02	3	36.7	34	39

Table B8. Observed fork length summary of chinook salmon at stranding sites near Ives Island in 2002.

Date	Number of Chinook	Fork Length (mm)		
		Mean	Minimum	Maximum
2/4/02	1	46	46	46
2/7/02	3	44	43	45
2/10/02	3	47.3	46	49
2/11/02	3	45	44	46
2/18/02	9	40.2	34	47
3/3/02	4	40	32	53
3/10/02	1	36	36	36
3/24/02	1	35	35	35
4/3/02	6	42.7	38	48
4/25/02	1	35	35	35
5/30/02	1	68	68	68
6/26/02	1	84	84	84

Table B9. Observed fork length summary of coho salmon at stranding sites near Ives Island in 2002

Date	Number of Coho	Fork Length (mm)		
		Mean	Minimum	Maximum
3/24/02	1	42	42	42
4/3/02	82	36.8	30	37
4/25/02	1	35	35	35

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 B10. Number of entrapped chum salmon found on entrapment sites marked by a particular dominant substrate near Ives Island in 2002. Numbers in ( ) represent mortalities.

Site Code	Dominant Substrate Code					
	1	**4**	**5**	**6**	**7**	**8**
E210-4			28			
E210-5			254			
E210-6			119			
E217-4				12		
E218-3				47		
E226-2					10	
E227-2		7 (7)				
E232-2	5					
E234-2					70 (1)	
E234-3					23	
E235-3					23 (1)	
E236-2					1	
E258	1					
E279						4
E279-2						1
E279-3						1
Total Number	**6**	**7 (7)**	**401**	**59**	**127 (2)**	**6**
Mean number per site visit	**3**	**7**	**133.7**	**29.5**	**25.4**	**2**
Median number per site visit	**3**	**7**	**119**	**29.5**	**23**	**1**

Table B11. Number of stranded chum salmon found on sites marked by a particular dominant substrate near Ives Island in 2002. Accompanying entrapment codes identify the stranding site as a dewatered entrapment. Numbers in ( ) represent mortalities (key on page 46).

Stranding Code	Entrapment Code	Dominant Substrate			
		1	5	6	7
S211	NA				1(1)
S214	NA		1(1)		
S215	E220			7(7)	
S216	NA			11(11)	
S217	E219			28(28)	
S218	E215				1(1)
S219	NA	2(2)			
S22O	NA	1(1)			
Total number		**3**	**1**	**46**	**2**
Mean number per site		**1.5**	**1**	**15.3**	**1**
Median number per site		**1.5**	**1**	**11**	**1**

Table B12. Number of entrapped chinook salmon found on sites marked by a particular dominant substrate near Ives Island in 2002. Numbers in ( ) represent mortalities (key, p. 46).

Site Code	Dominant Substrate Code					
	1	4	5	6	7	8
E204					2	
E205						1
E210-1, 2, 4, 5, 6			291			
E215					2	
E217-2				1		
E217-3				1 (1)		
E218				3 (3)		
E218-2				3(3)		
E218-3				6		
E219				6 (6)		
E221	4 (4)					
E222	1 (1)					
E226-2					6	
E229					1	
E232-2	5					
E234					6	
E234-2					28	
E234-3					4	
E235-2					3	
E235-3					71	
E236-2					2	
E264-1, 2, 3, 4	28					
E268	1 (1)					
E269	48 (2)					
E269-2	68					
E269-3	8					
E274	189					
E274-2	19					
E274-4	21					
E275-2				10		
E279						27
E279-2						171
E279-3						20
E279-4						21
E279-5						2
Total Number	**392(8)**	**0**	**291**	**30(13)**	**125**	**242**
Mean number per site visit	**28**	**0**	**58.2**	**4.3**	**12.5**	**40.3**
Median number per site visit	**8**	**0**	**56**	**3**	**3.5**	**20.5**

Table B13. Number of <u>stranded</u> chinook salmon found on sites marked by a particular dominant substrate near Ives Island in 2002. Accompanying entrapment codes identify the stranding site as a dewatered entrapment. Numbers in ( ) represent mortalities (key, p. 46).

Stranding Code	Entrapment Code	Dominant Substrate						
		1	3	4	5	6	7	8
S201	NA						1(1)	
S202	NA				3(3)			
S203	NA			2 (live)				
S204	E202		1(1)					
S205	E219					2(2)		
S206	E220					1(1)		
S207	E217					2(2)		
S208	E219					7(7)		
S209	E219					1(1)		
S210	E218					3(3)		
S212	NA			1(1)				
S213	E227			1(1)				
S216	NA					1(1)		
S217	E219					5(5)		
S220	NA	1(1)						
S221	E267						1(1)	
S222	NA							1(1)
Total number		**1**	**1**	**4**	**3**	**22**	**2**	**1**
Mean number per site		**1**	**1**	**1.3**	**3**	**2.75**	**1**	**1**
Median number per site		**1**	**1**	**1**	**3**	**2**	**1**	**1**

Table B14. Number of entrapped coho salmon found on entrapment sites marked by a particular dominant substrate near Ives Island in 2002. Numbers in ( ) represent mortalities (key, P. 46).

Site Code	Dominant Substrate Code					
	1	**4**	**5**	**6**	**7**	**8**
E210-3	3					
E210-4	39 (1)					
E210-5	91					
E210-6	43					
E218-3				43		
E226-2					1	
E232-2	1					
E234-2					37	
E234-3					6	
E235-2					3	
E235-3					17	
E236-2					3	
E274	43					
E274-2	8					
E274-3	1					
E279						12
E279-2						62
E279-3						1
E279-4						2
Total Number	**229 (1)**	**0**	**0**	**43**	**67**	**77**
Mean number per site visit	**28.6**	**0**	**0**	**43**	**11.2**	**19.3**
Median number per site visit	**23.5**	**0**	**0**	**43**	**4.5**	**7**

Table B15. Number of <u>stranded</u> coho salmon found on sites marked by a particular dominant substrate near Ives Island in 2002. Accompanying entrapment codes identify the stranding site as a dewatered entrapment. Numbers in ( ) represent mortalities (key, p. 46).

Stranding Code	Entrapment Code	Dominant Substrate Code	
		4	6
S213	E227	1(1)	
S215	E220		4(4)
S216	NA		10(10)
S217	E219		68(68)
S219	NA	1(1)	
Total number		**2**	**82**
Mean number per site		**1**	**27.3**
Median number per site		**1**	**10**

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 B16. Number of threatened chum salmon found at entrapment sites with a given substrate embeddedness near Ives Island of the Columbia River in 2002. Numbers in ( ) represent mortalities.

Site Code	Embeddedness			
	1	2	3	4
E226-2	10			
E234-2	70 (1)			
E234-3	23			
E235-3	23 (1)			
E236-2	1			
E279	4			
E279-2	1			
E279-3	1			
E210-4		28		
E210-5		254		
E210-6		119		
E217-4			12	
E218-3			47	
E227-2			7 (7)	
E232-2				5
E258				1
Total number	**133 (2)**	**401**	**66 (7)**	**6**
Mean number per site visit	**16.7**	**133.7**	**22**	**3**
Median number per site visit	**7**	**119**	**12**	**3**

Table B17. Number of threatened chum salmon found at stranding sites with a given substrate embeddedness near Ives Island of the Columbia River in 2002. Accompanying entrapment codes identify the stranding site as a dewatered entrapment. Numbers in ( ) represent mortalities (key, p. 52).

Stranding Code	Entrapment Code	Embeddedness Code			
		1	2	3	4
S211	NA			1(1)	
S214	NA	1(1)			
S215	E220			7(7)	
S216	NA	11(11)			
S217	E219			28(28)	
S218	E215	1(1)			
S219	NA				2(2)
S22O	NA				1(1)
Total number		**13**	**0**	**36**	**3**
Mean number per site		**4.3**	**0**	**12**	**1.5**
Median number per site		**1**	**0**	**7**	**1.5**

Table B18. Number of chinook salmon found at entrapment sites with given substrate embeddedness near Ives Island of the Columbia River in 2002. Numbers in ( ) represent mortalities (key, p. 52).

Site Code	Embeddedness			
	1	2	3	4
E215	2			
E226-2	6			
E229	1			
E234-1, 2, 3	38			
E235-2	3			
E235-3	71			
E236-2	2			
E275-2	10			
E279	27			
E279-2	171			
E279-3	20			
E279-4	21			
E279-5	2			
E210		57		
E210-2		14		
E210-5		56		
E210-6		56		
E204			2	
E205			1	
E217-2, 3			2 (1)	
E218			3 (3)	
E218-2			3 (3)	
E218-3			6	
E219			6 (6)	

E268			1 (1)	
E210-4				108
E221				4 (4)
E222				1 (1)
E232-2				5
E264-1, 2, 3, 4				28
E269				48 (2)
E269-2				68
E269-3				8
E274				189
E274-2				19
E274-4				21
Total number	**374**	**183**	**24 (14)**	**499 (7)**
Mean number per site	**24.9**	**45.8**	**2.7**	**32.3**
Median number per site	**6**	**56**	**2**	**8**

Table B19. Number of chinook salmon found at stranding sites with given substrate embeddedness near Ives Island of the Columbia River in 2002. Accompanying entrapment codes identify the stranding site as a dewatered entrapment. Numbers in ( ) represent mortalities (key, p. 52).

Stranding Code	Entrapment Code	Embeddedness Code			
		1	2	3	4
S201	NA			1(1)	
S202	NA			3(3)	
S203	NA			2(live)	
S204	E202			1(1)	
S205	E219			2(2)	
S206	E220			1(1)	
S207	E217			2(2)	
S208	E219			7(7)	
S209	E219			1(1)	
S210	E218			3(3)	
S212	NA				1(1)
S213	E227			1(1)	
S216	NA	1(1)			
S217	E219			5(5)	
S220	NA				1(1)
S221	E267		2(2)		
S222	NA			1(1)	
Total number		**1**	**2**	**30**	**2**
Mean number per site		**1**	**2**	**2.3**	**1**
Median number per site		**1**	**2**	**2**	**1**

Table B20. Number of coho salmon found at entrapment sites with given substrate embeddedness near Ives Island of the Columbia River in 2002. Numbers in ( ) represent mortalities (key, p. 52).

Site Code	Embeddedness			
	1	2	3	4
E226-2	1			
E234-2	37			
E234-3	6			
E235-2	3			
E235-3	17			
E236-2	3			
E279	12			
E279-2	62			
E279-3	1			
E279-4	2			
E210-4		39 (1)		
E210-5		91		
E210-6		43		
E218-3			43	
E210-3				3
E232-2				1
E274				43
E274-2				8
E274-3				1
Total number	**144**	**173 (1)**	**43**	**56**
Mean number per site	**14.4**	**57.7**	**43**	**11.2**
Median number per site	**4.5**	**43**	**43**	**3**

Table B21. Number of coho salmon found at stranding sites with given substrate embeddedness near Ives Island of the Columbia River in 2002. Accompanying entrapment codes identify the stranding site as a dewatered entrapment. Numbers in ( ) represent mortalities (key, p.52).

Stranding Code	Entrapment Code	Embeddedness Code			
		1	2	3	4
S213	E227			1(1)	
S215	E220			4(4)	
S216	NA	10(10)			
S217	E219			68(68)	
S219	NA				1(1)
Total number		**10**	**0**	**73**	**1**
Mean number per site		**10**	**0**	**24.3**	**1**
Median number per site		**10**	**0**	**4**	**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 B22. Number of threatened chum salmon observed at entrapment sites with given vegetation densities near Ives Island of the Columbia River in 2002. Numbers in ( ) represent mortalities.

Site Code	Vegetation Density			
	0	1	2	3
E210-4				28
E210-5				254
E210-6				119
E217-4		12		
E218-3		47		
E226-2		10		
E227-2		7(7)		
E232-2				5
E234-2				70(1)
E234-3				23
E235-3				23(1)
E236-2			1	
E258				1
E279				4
E279-2				1
E279-3				1
Total Number	**0**	**76(7)**	**1**	**529(2)**
Mean Number per Sampling	**0**	**19**	**1**	**48.1**
Median Number per Sampling	**0**	**11**	**1**	**23**

Table B23. Number of threatened chum salmon observed at stranding sites with given vegetation densities near Ives Island of the Columbia River in 2002. Accompanying entrapment codes identify the stranding site as a dewatered entrapment (key). Numbers in ( ) represent mortalities.

Stranding Code	Entrapment Code	Vegetation Density Code			
		0	1	2	3
S211	NA		1(1)		
S214	NA		1(1)		
S215	E220		7(7)		
S216	NA		11(11)		
S217	E219		28(28)		
S218	E215	1(1)			
S219	NA			2(2)	
S22O	NA			1(1)	
Total number		**1**	**48**	**3**	**0**
Mean number per site		**1**	**9.6**	**1.5**	**0**
Median number per site		**1**	**7**	**1.5**	**0**

Table B24. Number of chinook salmon observed at entrapment sites with given vegetation densities near Ives Island of the Columbia River in 2002. Numbers in ( ) represent mortalities (key, p. 57).

Site Code	Vegetation Density Code			
	0	1	2	3
E204		2		
E205		1		
E210		57		
E210-2				14
E210-4				108
E210-5				56
E210-6				56
E215		2		
E217-2		1		
E217-3		1(1)		
E218-1		3(3)		
E218-2		3(3)		
E218-3		6		
E219		6(6)		
E221		4(4)		
E222		1(1)		
E226-2		6		
E229		1		
E232-2				5
E234-1		6		
E234-2				28
E234-3		4		
E235-2		3		
E235-3				71
E236-2			2	
E264-1			11	
E264-2			3	
E264-3			8	
E264-4			6	
E268			1(1)	
E269-1				48(2)
E269-2				68
E269-3				8
E274-1				189
E274-2				19
E274-4				21
E275-2		10		
E279-1				27
E279-2				171
E279-3				20
E279-4				21
E279-5				2
Total Number	**0**	**117(18)**	**31(1)**	**932(2)**
Mean Number per Site	**0**	**6.5**	**5.2**	**51.8**
Median Number per Site	**0**	**3**	**4.5**	**27.5**

Table B25. Number of chinook salmon observed at stranding sites with given vegetation densities near Ives Island of the Columbia River in 2002. Accompanying entrapment codes identify the stranding site as a dewatered entrapment (key, p. 57). Numbers in ( ) represent mortalities (key, p. 57).

Stranding Code	Entrapment Code	Vegetation Density Code			
		0	1	2	3
S201	NA		1(1)		
S202	NA		3(3)		
S203	NA		2(live)		
S204	E202	1(1)			
S205	E219		2(2)		
S206	E220		1(1)		
S207	E217		2(2)		
S208	E219		7(7)		
S209	E219		1(1)		
S210	E218		3(3)		
S212	NA	1(1)			
S213	E227		1(1)		
S216	NA		1(1)		
S217	E219		5(5)		
S220	NA			1(1)	
S221	E267		1(1)		
S222	NA				1(1)
Total number		**2**	**30**	**1**	**1**
Mean number per site		**1**	**2.3**	**1**	**1**
Median number per site		**1**	**2**	**1**	**1**

Table B26. Number of coho salmon observed at entrapment sites with given vegetation densities near the Ives Island of the Columbia River in 2002. Numbers in ( ) represent mortalities (key, p. 57).

Site Code	Vegetation Density Code			
	0	1	2	3
E210-3				3
E210-4				39(1)
E210-5				91
E210-6				43
E218-3		43		
E226-2		1		
E232-2				1
E234-2				37
E234-3		6		
E235-2		3		
E235-3				17
E236-2			3	
E274-1				43
E274-2				8
E274-3				1
E279-1				12
E279-2				62
E279-3				1
E279-4				2
Total Number	**0**	**53**	**3**	**360(1)**
Mean Number per Sampling	**0**	**13.25**	**3**	**25.7**
Median Number per Sampling	**0**	**4.5**	**3**	**14.5**

Table B27. Number of coho salmon observed at <u>stranding</u> sites with given vegetation densities near the Ives Island of the Columbia River in 2002. Accompanying entrapment codes identify the stranding site as a dewatered entrapment. Numbers in ( ) represent mortalities (key, p. 57).

Stranding Code	Entrapment Code	Vegetation Density Code			
		0	1	2	3
S213	E227		1(1)		
S215	E220		4(4)		
S216	NA		10(10)		
S217	E219		68(68)		
S219	NA			1(1)	
Total number		**0**	**83**	**1**	**0**
Mean number per site		**0**	**20.7**	**1**	**0**
Median number per site		**0**	**7**	**1**	**0**