Deepwater Spawning of Fall Chinook Salmon (*Oncorhynchus tshawytscha*) near Ives and Pierce Island of the Columbia River

Annual Report 2004 - 2005

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

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**Deepwater Spawning of Fall
Chinook Salmon (*Oncorhynchus tshawytscha*)
near Ives and Pierce Island of the
Columbia River, 2004**

Annual Report

2004 - 2005

Prepared by:

Robert P. Mueller

Pacific Northwest National Laboratory
Richland, WA 99352

Prepared for:

U.S. Department of Energy
Bonneville Power Administration
Division of Fish and Wildlife
P.O. Box 3621
Portland, OR 97208

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Executive Summary

Pacific Northwest National Laboratory conducted video-based boat surveys to identify fall Chinook salmon (*Oncorhynchus tshawytscha*) spawning areas located in deep water (greater than 1 m) downstream of Bonneville Dam in fall 2004. This report documents the number and extent of Chinook salmon spawning near Ives and Pierce Islands of the Columbia River and is the sixth in a series of reports prepared since 1999. The main objectives of this study were to find deepwater spawning locations of fall Chinook salmon in the main Columbia River channel, collect additional data on physical habitat parameters at spawning sites, and provide estimates of adult spawners in the surveyed area. The primary search area was adjacent to the upper portion of Pierce Island, and the secondary search zone was downstream of this area near the lower portion of Pierce Island. A secondary objective was to document the occurrence of any chum salmon (*O. keta*) redds in the deeper sections downstream of Hamilton Creek (slough zone search area).

Fall Chinook salmon redd numbers were down slightly from the record number found during 2003. The number of fall Chinook redds found in the Ives–Pierce Island complex (river km 228.5) during 2004 was 293, which does not include the number of shallow water redds found by visual observation by boat by the Oregon Department of Fish and Wildlife. The redds encompassed an area of 14.6 ha occurring adjacent to the lower part of Ives Island and Pierce Island. Peak spawning activity, based on redd counts and live fish seen near redds, was on or near November 16, 2004. An expanded redd count based on percentage video coverage in the primary and secondary search zones was 3,198 fall Chinook salmon redds at water depths exceeding approximately 1.0 m (approximately 125 kcfs) with an estimated spawning population of 10,800. Fall Chinook salmon redds were found at water depths from 1.07 to 7.6 m and were constructed predominantly of medium cobbles ranging in size from 7.6 to 15.2 cm in diameter. Near-bed water velocity readings taken in the secondary search ranged from 0.04 to 0.98 m/s (median 0.45 m/s). No chum salmon redds were found in a limited area within the relatively deeper sections of Hamilton Slough below Hamilton Creek. No additional salmon or chum redds were found in other areas searched, including near Woodward, Tanner, and McCord Creeks.

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1.0 Introduction

Since 1993, fall Chinook salmon (*Oncorhynchus tshawytscha*) have used Ives and Pierce Islands downstream of Bonneville Dam for spawning (Hymer 1997). Two stocks of fall Chinook salmon spawn in the area—lower river or Tule, currently listed as threatened (U.S. Fish and Wildlife Service 1999), and upriver bright stock, most of which spawn in the Hanford Reach of the Columbia River (Huntington et al. 1996). The size of this population was estimated at 1,800 to 5,200 fish from 1994 to 1996 (Hymer 1997). More recently, an adult population of 1,881 adult fish was estimated in 2002 (van der Naald et al. 2004) and 1,533 in 2003 (van der Naald et al. 2005). These estimates are based on carcass tagging and recoveries near shallow water and do not take into account fish that spawn nearer the main river channel in water depth exceeding approximately 2 m.

Pacific Northwest National Laboratory (PNNL)¹ has conducted underwater video surveys from 1999 through 2004 downstream of Bonneville Dam. The primary objectives in 2004 were to locate and map deepwater (greater than 1 m) spawning areas of fall Chinook salmon near the main Columbia River channel and to collect additional data on the physical habitat at spawning sites. The secondary objective was to map any chum salmon (*O. keta*) redds located in deeper sections in and around Ives and Pierce Islands.

2.0 Methods

The survey area consisted of three different search zones approximately 3.5 km downstream of Bonneville Dam near river km 228.5. The primary zone (125,000 m²) along the main channel side of Pierce Island was segmented into regularly spaced transects, 20 m apart and 160 m long (37 total), running perpendicular to the shoreline. An additional eight transects were run at 20-m spacing immediately upstream of the primary zone during the 2003 surveys. The secondary zone (60,350 m²) was at the lower end of Pierce Island and consisted of 18 additional transects, 25 m apart and 120 m long. The third search zone (slough area) consisted of two separate areas. The first was at the lower end of Pierce Island, and the second was within Hamilton Slough between Ives and Pierce Islands (Figure 1). These areas were established based on previous surveys that documented fall Chinook and chum salmon redd occurrences (Mueller and Dauble 2000; Mueller 2001, 2002, 2003, 2004).

Two separate underwater video boat surveys were conducted in late November and early December 2004. The surveys were conducted just after November 16, the peak spawning date for fall Chinook salmon. This date was based on visual observations of adult fish by the Oregon Department of Fish and Wildlife (ODFW).

The boat-deployed video system consisted of a high-sensitivity remote camera (DeepSea Multi-SeaCam[®] Model 1050) attached to a weighted platform or sled. The camera was positioned at a slight angle forward from vertical so that redd characteristics (bed elevation) could be detected more easily. Recordings were made using an 8-mm digital recorder (Sony Model GVD 7000) situated on the survey vessel; two high-resolution monitors for real-time viewing of the video obtained by the remote camera

¹ Pacific Northwest National Laboratory is a multiprogram national laboratory operated by Battelle for the U.S. Department of Energy.

also were aboard the survey vessel. An integrated video/tow cable attached to a manual winch with slip ring mechanisms was used to raise and lower the sled to the desired depth. The presence of disturbed cobble indicated by changes in background contrast as well as “tail-spill” piles were the primary criteria used to determine spawning activity.

Figure 1. Location of Search Zones in Relation to Ives and Pierce Islands

The coverage area varied throughout the survey period and was influenced by ambient light levels, water clarity, boat speed, and, to a lesser extent, bottom slope and composition. The distance from the camera lens to the substratum averaged approximately 1.2 m, providing an effective coverage area of approximately 2.5 m² at any one location along each transect. The approximate vertical coverage along each transect was 1.2 m.

An on-board, real-time differential global positioning system (DGPS) (Trimble Pathfinder[®] Pro XR) was used to collect positional data and to navigate on preset transect grids during the surveys. The integrated DGPS beacon receiver and antenna provided DGPS corrections to calculate accuracy to below approximately 0.5 m. The system software (ASPEN) displayed a background map of the study site on a personal computer so that researchers could navigate to site locations on a predetermined transect line and visually verify data accuracy in the field. Both the DGPS and video system were synchronized via a time stamp. When a redd was encountered, the time was noted in the logbook; the notation was later associated with a GPS position. Further analysis and verification of redds was performed at PNNL in Richland, Washington. The location of any new redds also was mapped to an Arc/View[®] geographic information system (GIS).

The type and size of the substratum were determined with underwater red lasers (C-Map Systems Model HL6312G). The lasers provided a reference scale within the camera image. The distance from the

camera lens to the substratum ranged from 0.9 to 1.4 m, providing an effective view path of approximately 2.5 m² along each transect. Grain size was determined by digitizing the image when the camera was positioned near the center portion of the redd and processing the image using an imaging software program (Optimas[®]). Three rocks were measured (long axis diameter) that constituted the dominant substrate size for each digitized image. An average of the three measurements was used to determine the actual substrate category for each redd. The substrate size for each redd was classified according to five general size categories (Table 1). Using the substrate category, we expanded these points, based on association with the nearest substrate type, to predict the substrate category where no data points were collected. We projected the GPS positions into the GIS (ArcView) and then used a script (Thiessen Polygons) to connect a series of point locations with line segments, erecting perpendiculars to those line segments at their midpoints, and then extending those perpendiculars until they intersected.

Table 1. Substrate Categories Used for Spawning Habitat Classification (modified from Platts et al. 1983)

Category	Sediment Classification	Long Axis Diameter of Individual Substrate (cm)
1	Fines, silt	<0.61
2	Gravel	0.6 – 7.6
3	Medium cobble	7.6 – 15.2
4	Large cobble	15.2 – 30.5
5	Boulder	>30.5

Near-bed water velocity point measurements were obtained with a Marsh-McBirney Flo-Mate flowmeter (Model 2000) positioned 20 to 22 cm above the substratum, with the weighted platform resting on the river bottom. A measurement was recorded after the display stabilized. Point velocities were measured throughout the secondary survey zone, approximately four measurements per transect (Appendix A). GIS maps were created using Thiessen Polygons to connect the point velocity locations with line segments, erecting perpendiculars to those line segments at their midpoints, and then extending those perpendiculars until they intersected. Mean near-bed velocities ranging from 0.1 to 2.0 m/s are considered to be favorable for fall Chinook salmon spawning activity (Groves and Chandler 1999).

To eliminate the possibility of counting a redd more than once during the two survey periods, we omitted any redds that fell within a 1.8-m radius of a nearby redd. This distance was based on an overall redd size of 10 m², which is indicative of fall Chinook salmon redds within the Columbia River (Burner 1951; Chapman et al. 1983; Visser 2000). In addition, the cumulative number of redds found during both survey periods was extrapolated to estimate the total number of redds constructed within the primary search zone. These estimates were calculated by taking the total number of redds found during each of the surveys and expanding this number based on the percentage of coverage (assuming normal distribution) within the total search zone. The total fall Chinook salmon redd estimates do not include redds found by other researchers conducting visual redd observations by boat.

Water turbidity was recorded using a LaMotte turbidimeter (Model 2008). Recorded tapes were reviewed in detail at the PNNL computer laboratory using a high-resolution monitor. Bathymetric data were obtained using a one-dimensional, unsteady river flow and water quality computer model, MASS1 (Modular Aquatic Simulation System 1D), developed at PNNL.

3.0 Results

A total of 293 fall Chinook salmon redds were found and mapped during surveys conducted in November and December 2004 (Figure 1). Initial deepwater redd surveys of the main channel near Ives and Pierce Islands were completed on November 22 and 24, 2004, shortly after the peak spawning date of November 16 for fall Chinook salmon (FPC 2004). River flows recorded at Bonneville Dam were quite variable, ranging from 121 to 170 kcfs (Table 2). The majority of the redds were mapped on November 22 and 23 when flows averaged 126.1 kcfs. A total of 193 fall Chinook redds were located and mapped within all surveys zones. This total includes 124 within the primary search zone, 63 in the secondary zone, and 6 additional redds found upstream of the primary search zone near the lower portion of Ives Island (Table 3). A separate survey was conducted in the slough zone downstream of Hamilton Creek. A total of seven transects were run within this zone, with water depths ranging from 0.6 to 2.7 m. Flows during this survey were near 127 kcfs (staff gage 1 = 0.98 ft), which precluded boat access in the area between Ives and Pierce Islands. Several chum carcasses were observed, but no confirmed redds were found during the limited search.

Table 2. Average River Flow and Elevation Conditions Recorded During the Underwater Video Survey Period

Date	Discharge at Bonneville Dam (average kcfs)	Ives Island Staff Gage 1 (ft)
November 22, 2004	126.7	0.88
November 23, 2004	125.5	1.0
November 24, 2004	170.0	3.7
December 8, 2004	151.8	3.4
December 9, 2004	102.8	1.6

Table 3. Number of Fall Chinook Redds Found in Primary and Secondary Search Zones 2004

Survey Date	Primary Zone (includes redds found at lower Ives Island)	Secondary Zone
November 22 through 24	130	63
December 8 and 9	72	28
Total	202	91

The second deepwater fall Chinook salmon redd survey was completed on December 8 and 9, 2004. River discharge at Bonneville Dam during the survey period ranged from 151.8 kcfs on December 8 and fell to 102.8 kcfs on December 9; water turbidity averaged 3.4 NTU. A total of 100 additional redds were found, including 72 in the primary search zone and 28 in the secondary zone. The maximum depth at which redds could be detected was 8.5 m during both surveys.

The location of all redds (n = 293) found during surveys conducted in 2004 is shown in Figure 2. The MASS1 model was superimposed on the river layer to illustrate the redds in relation to water depth at a river flow of 125 kcfs at Bonneville Dam.

Figure 2. Location of Fall Chinook and Chum Salmon Redds (n = 293) in the Mainstem of the Columbia River Below Bonneville Dam in 2004

Water depths at redd locations ranged from 0.3 to 6.7 m (median = 3.0 m) in the primary and 3.0 to 7.92 m (median = 4.8 m) in the secondary zone at a river flow of approximately 123 kcfs (Figure 3).

Dominant substrate measurements were measured from the majority of the redds found using the lasers for scaling. The long axis diameter from 120 redds found in the primary search zone ranged from 7.0 to 18 cm (median = 10.0 cm) and 6.9 to 13.2 cm (median = 9.0 cm) in the secondary zone (n = 61). The substrate sizes were fairly uniform throughout the primary and secondary spawning zones and mostly fell into the medium cobble category (Figures 4 and 5). Only 16 redds were found in the gravel category and 2 in the large cobble category.

The Hamilton Slough survey was conducted on November 23, 2004. Low water elevation precluded surveys in the channel between Ives and Pierce Islands. A total of four carcasses were found, but no redds were observed. Additional chum or coho (*O. kisutch*) salmon carcasses were found at the mouth of Woodward Creek. We did not find any salmon redds during limited surveys at the mouths of Woodward, McCord, and Tanner Creeks.

Figure 3. Distribution of Fall Chinook Salmon Redds (n = 292) Relative to Water Depth During the November and December 2004 Surveys in the Primary and Secondary Search Zones (flow approximately 123 kcfs)

Figure 4. Dominant Substrate Classification of Fall Chinook Salmon Redds (n = 186) in the Primary and Secondary Search Zones

Figure 5. Substrate Composition Within the Fall Chinook Spawning Zones and Redds Found in 2004

The total area used by fall Chinook salmon for spawning was calculated by drawing a boundary line around the redd locations within the primary and secondary zones. A maximum convex polygon was created from points recorded above all salmon redds at both the upper and lower spawning areas. The radius of the polygon was then buffered 3 m to account for the redd areas that defined the polygon vertices. This buffer was then combined with the convex polygon, and the area was calculated. The area where redds were found encompassed 9.74 ha in the primary and 4.92 ha in the secondary zone (Figure 6). Additional maps showing how the spawning area has changed over the period from 1999 through 2004 are shown in Appendix B.

Near-bed water velocity readings were measured on December 9 at a river discharge of 105 kcfs. The water velocities ranged from 0.04 to 0.98 m/s (median 0.45 m/s). The interpolated map shows the majority of the redds were found where velocities were 0.3 m/s or greater. Velocities increased to near 1.0 m/s along the southern part of this zone nearest the main river channel.

During the past 4 years of deepwater redd surveys by PNNL, a total population of spawning fish was estimated by extrapolating the redd count based on the portion of the area surveyed by video camera. The average vertical coverage along each transect line was estimated to be approximately 1.2 m. This measurement was averaged during the two survey periods. Because the boat route varied somewhat along the line of each transect, the distance traveled along each transect varied. The actual redd count was used to estimate the total number of redds that may be present in the overall survey zone, assuming equal distribution throughout the two zones. Approximately 6.5% of the primary and 5.2% of the secondary zone were surveyed by the video camera. To estimate the total spawning population within the spawning

zones (Figure 7), a multiplier of 3.4 adult fish for each redd was used (Visser 2000). Using this multiplier, approximately 10,800 fish were present during the peak spawning period in mid-November 2004 (Table 4).

Figure 6. Fall Chinook Salmon Spawning Area for Redds Found During 2004

Figure 7. Near-Bed Water Velocity Measurements Taken December 9, 2004 (secondary zone) and Redd Locations (river flow approximately 105 kcfs)

Table 4. Estimated Number of Fall Chinook Salmon Redds Occurring in the Primary Search and Secondary Zone near Ives and Pierce Islands near the Peak Spawning Period, November 22 and 23, 2004

Location	Total Area Surveyed (m ²) ^(a)	Video Coverage (%)	Number of Redds Found	Extrapolated Redd Estimate	Adult Population Estimate
Primary	6,614	6.5	130	1,985	6,749
Secondary	2,958	5.2	61	1,152	3,115
Total	9,572		191	3,137	9,864
(a) Area encompassed the survey boat track and average transect length in each survey zone based on a 1.2-m video field view along each transect.					

In addition to the deepwater surveys conducted by PNNL during 2004, personnel from ODFW counted a total of 111 fall Chinook salmon redds on November 9 through 16, 2004, by wading or boat in water depths less than 2 m. These redds were located at the upper part of Pierce Island and in the shallow channel between Ives and Pierce Islands (FPC 2004).

4.0 Discussion

A total of 293 fall Chinook salmon redds were found to occur near the vicinity of Ives and Pierce Islands downstream of Bonneville Dam in 2004. This number is slightly lower than the record number of redds found in 2003 when 336 redds were found. We continue to observe a larger portion of redds in the lower portion of Pierce Island (secondary zone) as the percentage of the total redds found increased from 3% in 2000 to 31% in 2004 (Figure 8). The overall spawning area was also the highest observed for 2004, growing from 4.0 ha in 1999 to 14.6 ha in 2004 (Table 5). No chum redds were found during our limited surveys. ODFW personnel documented chum spawning near the mouth of Hamilton Creek, one fall Chinook salmon in the slough area near the north river bank, and 37 redds in the channel between Ives and Pierce Islands.

The maximum water depths at which redds were detected during 2004 was 7.9 m. At 3.4 NTU, water turbidity was higher than what we experienced during surveys in previous years. Ideal turbidity levels for visual detection would be in the 1- to 2-NTU range. Turbidity values exceeding 4 NTU can limit the ability to detect redds in water depths greater than 6 m (Dauble et al. 1999). Mean near-bed water velocity measurements within the suitable regions were generally on the very low end of the preferred criteria scale (0.45 m/s). All redds mapped within the secondary zone were located in areas where water velocities exceeded 0.31 m/s. Groves and Chandler (1999) reported mean substrate level velocities of 0.88 m/s on 164 fall Chinook redds below Hells Canyon Dam from 1993 through 1995. Water velocity measured near the bed within the secondary zone showed an increasing value toward the main river channel. River flows were consistent during the first survey period at approximately 126 kcfs and varied from 151 to 102 kcfs during the second survey.

Figure 8. Historical Perspective of Redd Proportions in the Primary and Secondary Search Zones near Pierce Island, 2004

Table 5. Fall Chinook Redd Counts and Approximate Spawning Areas from 1999 Through 2004 near Ives and Pierce Islands

Year	Redds (n)	Approximate Spawning Area (ha)
1999	64	4.0
2000	76	6.3
2001	43	4.9
2002	192	9.3
2003	336	13.7
2004	293	14.6

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Appendix A

Near-Bed Water Velocity Point Measurements, 2004

Appendix A

Near-Bed Water Velocity Point Measurements, 2004

Bed Velocity Coordinate Description

Projection	Stateplane
Zone	WA South 4602
Datum	NAD27
Units	US Survey feet

No.	Northing	Easting	Depth (m)	Bed Velocity (m/s)
1	107142.173	1614581.397	3.4	0.41
2	107072.576	1614687.607	5.0	0.81
3	107056.633	1614705.198	5.3	0.79
4	107056.366	1614585.334	5.2	0.33
5	107153.685	1614545.487	3.2	0.53
6	107247.403	1614507.000	2.1	0.54
7	107308.505	1614486.912	1.4	0.48
8	107280.202	1614386.289	1.4	0.04
9	107126.036	1614439.031	3.0	0.64
10	107040.844	1614458.288	5.3	0.69
11	107019.798	1614474.421	6.4	0.98
12	107006.141	1614367.311	6.1	0.25
13	107063.410	1614374.179	4.6	0.52
14	107067.494	1614367.561	4.3	0.58
15	107204.698	1614309.647	2.4	0.50
16	107132.824	1614208.007	3.0	0.32
17	107081.723	1614279.598	4.1	0.48
18	107010.763	1614261.129	5.8	0.50
19	106991.520	1614142.887	6.7	0.54
20	107017.252	1614148.393	5.5	0.41
21	107074.928	1614160.566	4.1	0.36
22	107192.287	1614135.965	1.8	0.28
23	107184.162	1614004.306	2.1	0.30
24	107100.313	1614078.092	3.4	0.53
25	107012.679	1614041.504	5.0	0.52

No.	Northing	Easting	Depth (m)	Bed Velocity (m/s)
26	106976.179	1614036.650	6.1	0.36
27	106996.882	1613989.175	6.6	0.50
28	107050.626	1613973.056	4.6	0.51
29	107137.692	1613977.545	3.0	0.32
30	107102.877	1613874.221	3.4	0.32
31	107051.632	1613918.252	4.3	0.45
32	106999.520	1613926.514	5.8	0.32
33	106960.039	1613913.719	7.0	0.43
34	106970.891	1613811.448	6.4	0.38
35	107053.401	1613815.297	5.2	0.30
36	107046.601	1613822.610	4.4	0.28
37	107159.098	1613808.252	3.0	0.18
38	107065.277	1613778.912	4.1	0.30
39	106998.575	1613765.985	5.6	0.49
40	106967.136	1613783.094	6.1	0.65
41	106963.131	1613699.319	0.0	0.38
42	106995.687	1613703.906	5.6	0.41
43	107071.183	1613707.971	4.3	0.35
44	107161.812	1613667.987	2.9	0.38
45	107136.812	1613560.530	3.4	0.31
46	106976.871	1613656.600	6.1	0.49
47	106991.494	1613586.236	5.9	0.52
48	107160.752	1613488.330	2.7	0.31
49	107139.594	1613453.294	2.7	0.42
50	107060.646	1613512.972	4.7	0.35
51	106957.242	1613547.093	6.7	0.72
52	106945.170	1613497.069	6.7	0.55
53	107019.987	1613474.782	5.6	0.38
54	107071.626	1613455.280	4.3	0.41
55	107236.759	1613373.091	2.1	0.28
56	106930.539	1613383.867	7.0	0.65
57	106934.197	1613340.188	6.7	0.59
58	107190.012	1613229.959	3.4	0.27
59	107181.734	1613099.487	3.8	0.38
60	107090.968	1613165.019	4.3	0.49
61	107000.693	1613207.738	5.8	0.54
62	106942.117	1613189.863	6.9	0.75

No.	Northing	Easting	Depth (m)	Bed Velocity (m/s)
63	106969.179	1613110.905	6.4	0.70
64	107126.203	1613076.430	5.0	0.54
65	107126.542	1613077.411	4.4	0.20
66	107208.891	1612994.995	3.4	0.21
67	107196.121	1612853.221	3.5	0.33
68	107071.211	1612950.669	5.2	0.52
69	106941.481	1612999.982	7.0	0.83
70	106925.917	1612900.867	7.0	0.62
71	106992.027	1612882.550	6.4	0.41
72	107150.016	1612847.649	4.3	0.25
73	107238.962	1612793.333	3.0	0.37
74	107243.421	1612603.978	2.7	0.32
75	107162.025	1612692.624	3.8	0.37
76	107042.659	1612772.954	5.5	0.35
77	106985.858	1612805.807	6.1	0.39
78	106949.220	1612740.842	7.0	0.65
79	107254.697	1612584.944	3.0	0.39
80	107274.869	1612460.092	3.5	0.27
81	107171.242	1612539.561	3.2	0.45
82	107021.000	1612627.426	5.6	0.44
83	106963.958	1612636.390	6.4	0.71
84	107027.255	1612534.087	5.6	0.56
85	107115.241	1612547.847	4.0	0.37
86	107284.616	1612399.415	4.0	0.26
87	107203.436	1612330.838	3.8	0.29
88	107137.953	1612382.578	4.1	0.37
89	107047.439	1612424.547	5.2	0.37
90	106982.622	1612477.830	6.2	0.65
91	106915.787	1612464.982	7.6	0.68
92	106979.217	1612425.647	6.4	0.61
93	107040.646	1612376.735	5.0	0.70
94	107128.625	1612347.534	3.5	0.48
95	107198.545	1612291.420	4.3	0.19
96	107194.986	1612235.313	4.6	0.22
97	107202.315	1612142.726	5.5	0.20
98	107113.939	1612193.670	4.6	0.43
99	107096.020	1612243.684	4.1	0.46

No.	Northing	Easting	Depth (m)	Bed Velocity (m/s)
100	106968.824	1612251.065	5.5	0.60
101	106936.828	1612254.261	6.7	0.77
102	106926.741	1612184.106	7.3	0.76
103	106965.444	1612152.831	5.6	0.50
104	107018.400	1612165.440	5.0	0.58
105	107093.801	1612164.160	4.6	0.56
106	107103.851	1612167.730	4.6	0.59
107	107104.218	1612119.999	5.0	0.41
108	107111.960	1612005.709	6.1	0.30
109	107050.874	1612050.554	5.6	0.46
110	107017.878	1612094.738	5.2	0.42
111	106916.792	1612106.337	7.0	0.72
112	106899.699	1612022.021	7.9	0.78
113	106940.653	1612010.695	6.4	0.70
114	106994.634	1611999.311	5.2	0.50
115	107055.265	1611991.594	5.8	0.42
116	107044.178	1611911.143	6.7	0.32
117	106971.474	1611911.407	5.8	0.56
118	106943.881	1611905.322	6.2	0.67
119	106886.417	1611904.144	7.3	0.88
120	106983.321	1611838.557	6.6	0.51

Appendix B

Maps Illustrating Fall Chinook Salmon Redd Spawning Areas, 1999 Through 2003

Appendix B

Maps Illustrating Fall Chinook Salmon Redd Spawning Areas, 1999 Through 2003