# Deepwater Spawning of Fall Chinook Salmon (Oncorhynchus tshawtscha) Near Ives and Pierce Island of the Columbia River

## Annual Report
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# Deepwater Spawning of Fall Chinook Salmon (*Oncorhynchus tshawytscha*) near Ives and Pierce Island of the Columbia River, 2003

## Annual Report 2003-2004

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# Summary

Pacific Northwest National Laboratory conducted video-based boat surveys in fall 2003 to identify spawning areas for fall Chinook salmon (*Oncorhynchus tshawytscha)* in deep water (>1 m) downstream of Bonneville Dam. This report documents the number and extent of Chinook salmon spawning near Ives and Pierce islands of the Columbia River, and is the fifth in a series of reports prepared since 1999. The primary objective of this study was 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 secondary objective was to document the occurrence of any chum salmon (*O. keta*) redds in the deeper sections near below Hamilton Creek.

Results from the 2003 study show a continuing trend upward in the number of fall Chinook salmon redds found within the survey zones. The number of fall Chinook redds found in the Ives Pierce Island complex (river km 228.5) has increased by a factor of five since the surveys began in 1999. The total number of redds found during 2003 was 336, which compares to 192 in 2002, 43 in 2001, 76 in 2000, and 64 in 1999. The redds encompassed an area of 13.7 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 24, 2003. An expanded redd count based on percentage of video coverage in the primary and secondary search zones was 3,218 fall Chinook salmon redds in water exceeding 1 m deep and flowing at about 125 kcfs. Fall Chinook salmon redds were found at water depths from 1.07 to 7.6 m and were constructed predominantly of medium cobbles ranging from 7.6 to 15.2 cm in diameter. Two chum salmon redds were found in a small location downstream from Hamilton Creek in water depths of approximately 1 m. No salmon redds were found in other areas searched, including near Woodward, Tanner, and McCord creeks.

# Acknowledgments

The author thanks Scott Titzler, Fenton Khan, Corey Duberstein, and Nate Phillips for their assistance in conducting the surveys, preparing map layers, and in analyzing the videotapes.

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# Introduction

Since 1993, fall Chinook salmon have used Ives and Pierce islands downstream of Bonneville Dam for spawning (Hymer 1997). Two stocks of fall Chinook salmon spawn in the area—1) lower river or Tule, currently listed as threatened (U.S. Fish and Wildlife Service 1999), and 2) 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 704 adult fish was estimated in 2000 (Van der Naald et al. 2000-2001) and 721 in 2001 (Van der Naald et al. 2001-2002). 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.

Pacific Northwest National Laboratory (PNNL) has conducted underwater video surveys from 1999 through 2003 downstream of Bonneville Dam. The primary objective was to locate and map deepwater (>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.

# Methods

The area surveyed in 2003 was similar to that of the 2002 study (Mueller 2003) and consisted of three different search zones approximately 3.5 km downstream of Bonneville Dam near river km 228.5. The primary zone (125,000 $m^2$) 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 8 transects were run at 20-m spacing immediately upstream of the primary zone during the 2003 surveys. The secondary zone (60,350 $m^2$) 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, with the first occurring at the lower end of Pierce Island and the second 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).

Two separate underwater video boat surveys were conducted in late November and early December 2003. The surveys were conducted just after November 24, 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).

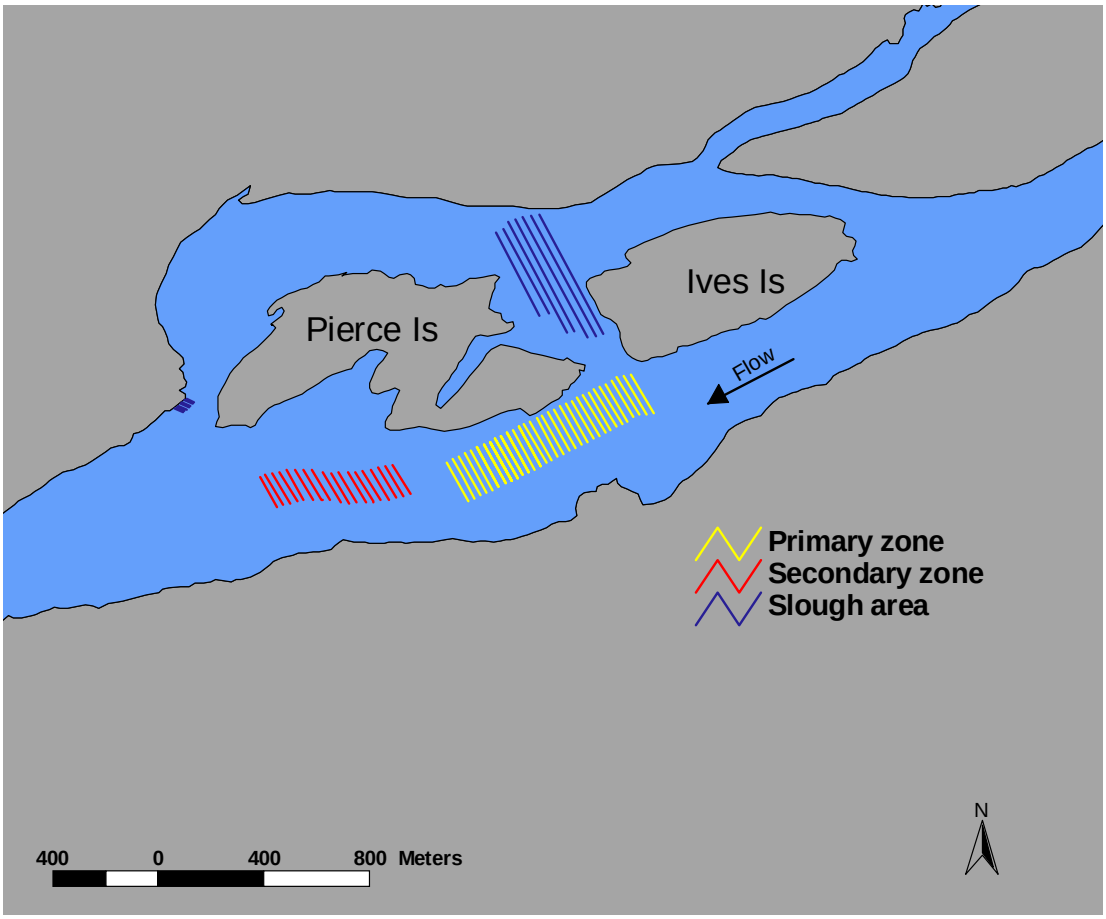



**Figure 1.** Location of search zones in relation to Ives and Pierce islands.

The boat-deployed video system consisted of a high-sensitivity remote camera (Deep Sea Model 1050) attached to a weighted platform. The camera was positioned at a slight angle upward from vertical so that redd characteristics (bed elevation) could be detected more easily. Recordings were made using a Sony digital 8-mm recorder (Model GVD 7000) situated on the survey vessel. Two high-resolution monitors were used during the surveys for better viewing of the video obtained by the remote camera. 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. Visual images of redds and bottom substrate were recorded using an underwater video system according to procedures described in Dauble et al. (1999). Redds were distinguished easily from the surrounding

substrate as areas of clean substrate, with a typical redd pit and tail spill shape, in contrast to areas of dark-colored (periphyton-covered) substrate. Live fish often were observed on the video screen when redds were found. The maximum depth at which adequate visual images could be obtained depended on water turbidity and ambient light levels. An on-board, real-time differential global positioning system (DGPS) (Trimble Pathfinder® Pro XR) was used to collect positional data and to navigate on pre-set 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 GPS 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 back at PNNL in Richland, Washington. The location of any new redds also was mapped to an Arc/View® graphic 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 $m^2$ along each transect (1.2 m vertical). 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).

**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 |

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 $m^2$, 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.

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.

# Results

Initial deepwater redd surveys of the main channel near Ives and Pierce islands were completed between November 18 and 20, 2003, near the peak spawning date of November 24 for fall Chinook salmon (FPC 2004). Water turbidity measured on November 18 was 3.2 nephelometric turbidity units (NTU), and river flows recorded at Bonneville Dam were relatively stable, ranging from 120 to 123 kcfs (Table 2). A total of 218 fall Chinook redds were located and mapped within all surveys zones. This total includes 153 within the primary search zone, 58 in the secondary zone, and 7 redds found upstream of the primary search zone near the lower portion of Ives Island. A separate survey was conducted downstream of Hamilton Creek and near the area between Ives and Pierce islands. A total of 10 transects were run within this zone, and water depths ranged from 0.6 to 3 m. Low water elevation precluded surveys immediately below Ives Island. Two chum salmon redds were found at about 1 m water depth approximately 640 m below Hamilton Creek (Figure 2). These were characterized by smaller grain sizes and smaller overall area.

The second deepwater fall chinook salmon redd survey was completed on December 2 and 3, 2003. River discharge at Bonneville Dam during the survey period ranged from 122 to 128 kcfs, and water turbidity averaged 2.3 NTU. A total of 118 additional redds were found, including 87 in the primary search zone and 31 in the secondary zone. Low water elevation precluded the surveying of the channel between Ives and Pierce islands; a river flow exceeding 135 kcfs is required to effectively survey this area. The maximum depth at which redds could be detected was 8.5 m during both surveys.

**Table 2**. Average river flow and elevation conditions recorded during the underwater video survey period.

| Date | Discharge at Bonneville Dam (ave kcfs) | Ives Island Staff Gage 1 (ft) |
|---|---|---|
| Nov. 18 | 123.5 | 1.03 |
| Nov. 19 | 120.6 | 1.0 |
| Nov. 20 | 122.4 | 0.92 |
| Dec. 2 | 128.1 | 1.04 |
| Dec. 3 | 122.2 | 0.91 |

The location of all redds (n = 338) found during surveys conducted in 2003 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.

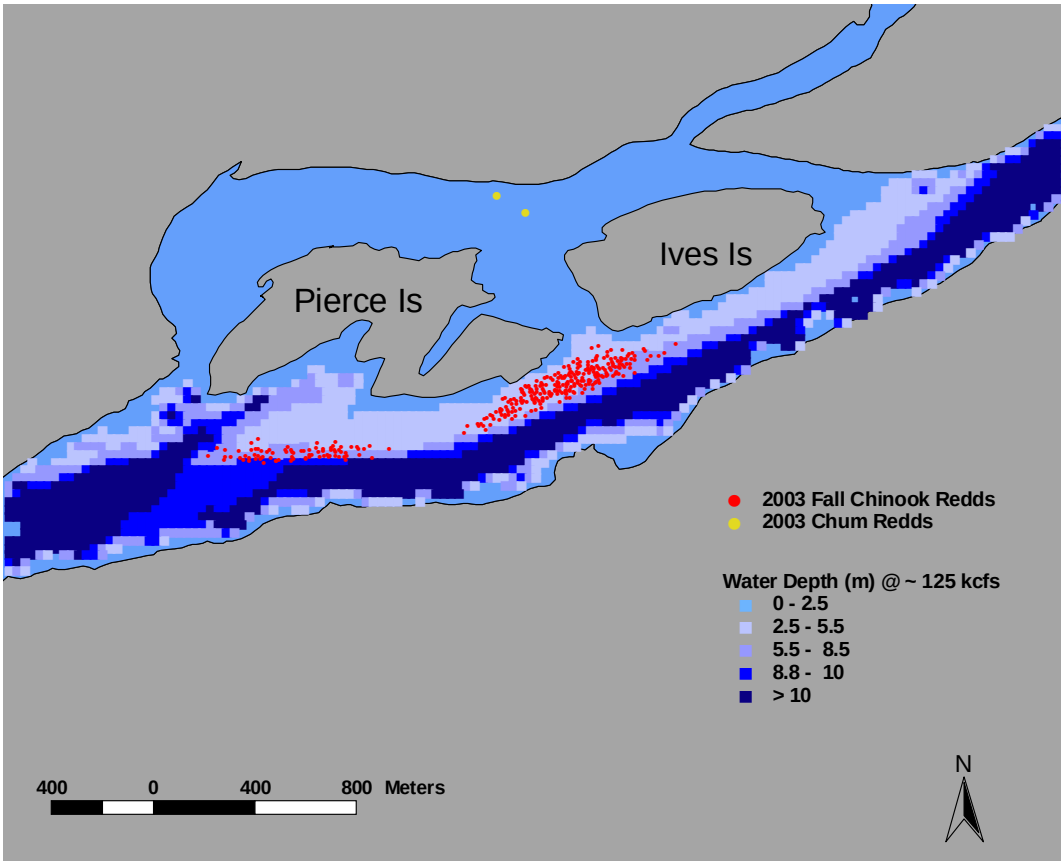



**Figure 2.** Location of fall Chinook and chum salmon redds (n = 338) in the mainstem of the Columbia River below Bonneville Dam in 2003.

Water depths at redd locations ranged from 1.07 to 6.1 m (median = 2.2 m) in the primary and 2.44 to 7.62 m (median = 5.1 m) in the secondary zone at a river flow of approximately 123 kcfs (Figure 3). Dominant substrate measurements were obtained from each redd found by using the lasers for scaling. The long axis diameter for a selected number of redds (n = 119) ranged from 7.3 to 15.9 cm (median = 10.16 cm) in the primary and 7.3 to 13.7 cm (median = 9.3 cm) in the secondary zone. As in measurements made during previous years, the bulk of the substrates used for redd construction fell into the medium cobble category (Figure 4). No redds were found in substrates with long axis diameters greater than 16 cm.

The Hamilton Slough survey was conducted on November 20, and two chum redds were found below the gravel bar at the mouth of Hamilton Creek. Several chum salmon carcasses were observed scattered throughout the search zone and 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.

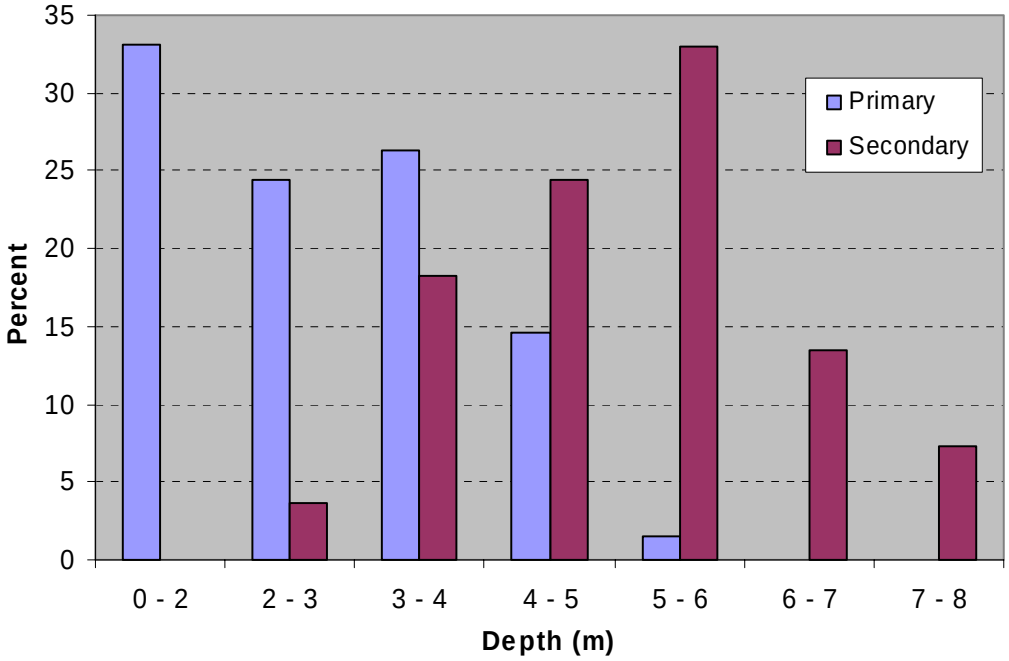



**Figure 3.** Distribution of fall Chinook salmon redds (n = 307) relative to water depth during the November and December 2003 surveys (flow ~123 kcfs).

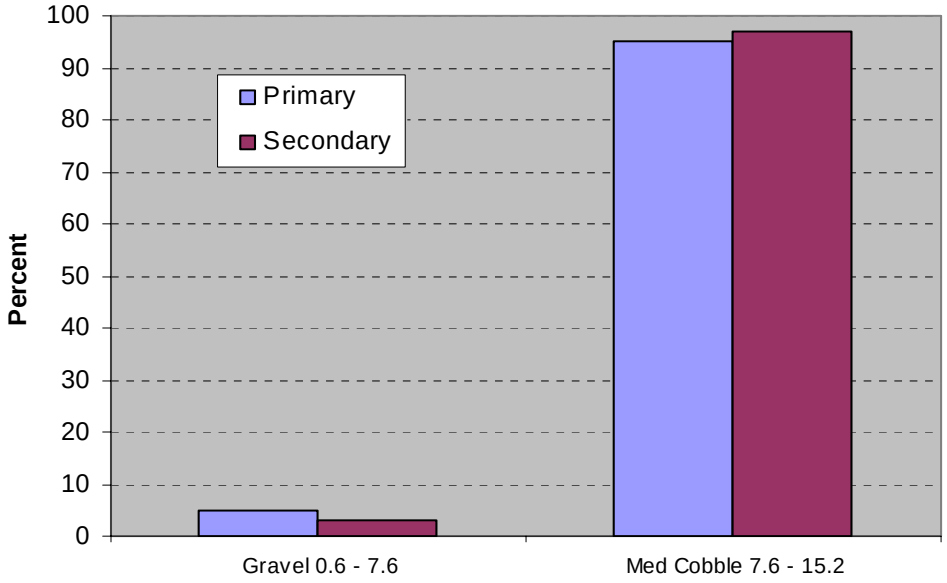



**Figure 4.** Dominant substrate classification of fall Chinook salmon redds (n = 119).

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. The area where redds were found encompassed 8.1 ha in the primary and 5.6 ha in the secondary zone (Figure 5). Additional maps showing how the spawning area has changed over the period from 1999 through 2002 are shown in Appendix A.

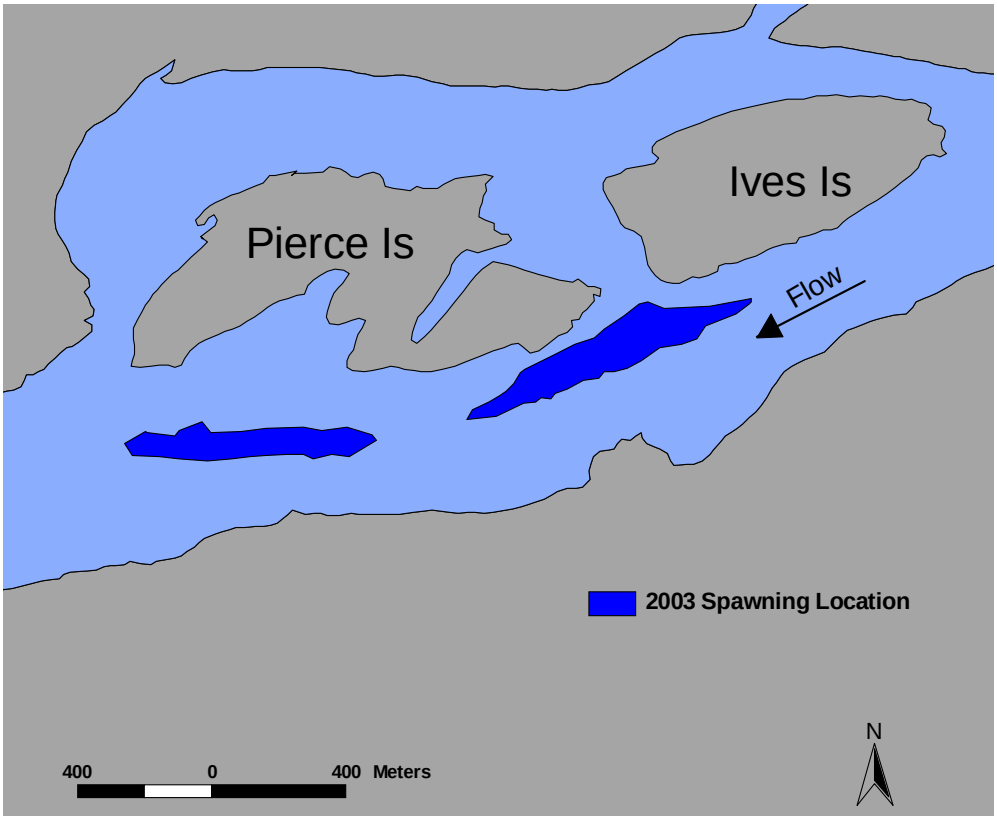



**Figure 5**. Fall Chinook salmon spawning area for redds found during 2003.

During the past four 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 6.6% of the primary and 6.2% of the secondary zone were surveyed by the video camera. To estimate the total spawning population within the spawning zones (Figure 6), a multiplier of 3.4 adult fish for each redd was used (Visser 2000). Using this multiplier,

approximately 11,000 fish were present during peak spawning period in mid-November 2003 (Table 3).

In addition to the deepwater surveys conducted by PNNL during 2003, personnel from the ODFW counted a total of 190 fall Chinook salmon redds at the estimated peak spawning date of November 25, 2003, within the Ives and Pierce islands area by wading or observation by boat (FPC 2004).

**Table 3.** Estimated number of fall Chinook salmon redds occurring in the primary search and secondary zone near Ives and Pierce islands during the peak spawning period, November 18 to 19, 2003**.**

| Location | Total Area Surveyed ($m^2$)* | Video Coverage (%) | Number of Redds Found | Extrapolated Redd Estimate | Adult Population Estimate |
|---|---|---|---|---|---|
| Primary | 6,066 | 6.6 | 153 | 2,295 | 7,803 |
| Secondary | 4275 | 6.2 | 58 | 923 | 3,138 |
| Total | 10,341 | | 211 | 3,218 | 10,941 |
| * 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. | | | | | |

# Discussion

A total of 336 fall Chinook salmon redds were found to occur near the vicinity of Ives and Pierce islands downstream of Bonneville Dam in 2003. This number exceeds the 2002 survey, when an estimated 192 redds were found, and is the highest number found since surveys began in 1999. The redd counts from the upriver bright fall Chinook salmon run that spawns in the Hanford Reach also were the highest on record, with an estimated 9,200 redds counted by aerial surveys (Poston et al. 2004). The majority of the fall Chinook salmon redds were found in the primary zone adjacent to Pierce Island, and the general area in which redds were found continued to increase from 4.0 ha in 1999 to 13.7 ha in 2003 (Table 4). A general increasing trend also was observed in the area used for spawning in the secondary zone; this area has increased from 1 ha in 2000 to 5.6 ha in 2003. Redds in this area were found at greater depths than those that occurred in the primary zone and were composed of similar-sized substrates. Only two chum salmon redds were found in the deeper section of Hamilton Slough that was surveyed.

**Table 4.** Fall Chinook redd counts and approximate spawning areas from 1999 through 2003 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 |

The maximum water depths at which redds could be detected during 2003 was 7.6 m. Somewhat high water turbidity during the first survey limited our ability to positively identify redds at depths exceeding 6 m. Based on previous surveys during the spawning period, a water turbidity in the range of 1 to 2 NTU is generally what can be expected, although high rainfall events can raise the turbidity to near 4 NTU, which limits the ability to document redds in deep water. Substrate measurements at redd sites were similar in composition to those of previous years, with medium cobbles of 7.6 to 15.2 cm being the most used followed by a small percentage using gravel. River flows measured at Bonneville Dam during both the November and December surveys were similar, averaging 123 kcfs.

## References


**Burner, C.J. 1951.** "Characteristics of spawning nests of Columbia River salmon." *Fishery Bulletin* 61, Volume 52. U.S. Fish and Wildlife Service, Washington, D.C.

**Chapman, D.W., D.E. Weitkamp, T.L. Welsh, and T.H. Schaldt. 1983**. *Effects of minimum flow regimes on fall chinook salmon spawning at Vernita Bar 1978-1982.* Don Chapman Consultants, McCall, Idaho, and Parametrix, Inc., Bellevue, Washington.

**Dauble, D.D., R.P. Mueller, R.L. Johnson, W.V. Mavros, and C.S. Abernethy. 1999**. *Surveys of fall chinook salmon spawning downstream of Lower Snake River hydroelectric projects. Summary Report for 1993-1998.* Prepared by Pacific Northwest Laboratory, Richland, Washington, for the U.S. Army Corps of Engineers, Walla Walla District, Walla Walla, Washington.

**FPC. 2004**. Fish Passage Center. http://www.fpc.org/Index.html. 2501 SW First Ave, Suite 230, Portland, Oregon.

**Huntington, C., W. Nehlsen, and J. Bowers. 1996**. "A survey of healthy native stocks of anadromous salmonids in the Pacific Northwest and California." *Fisheries* 21:6-14.

**Hymer, J. 1997**. *Results of studies on chinook spawning in the mainstem Columbia River below Bonneville Dam*. Columbia River Progress Report 97-9. Washington Department of Fish and Wildlife, Battle Ground, Washington.

**Mueller, R.P., and D.D. Dauble 2000**. *Evidence of deepwater spawning of fall chinook salmon (Oncorhynchus tshawytscha) spawning near Ives and Pierce Islands of the Columbia River.* Annual 1999, Report to Bonneville Power Administration, Contract No. 00000652-2, Project No. 1999-00304, 19 electronic pages (BPA Report DOE/BP-00000652-2).

**Mueller, R.P. 2001.** *Deepwater spawning of fall chinook salmon (Oncorhynchus tshawytscha) near Ives and Pierce Island of the Columbia River,* Annual 2000, Report to Bonneville Power Administration, Contract No. 00000652, Project No. 1999-00304, 27 electronic pages (BPA Report DOE/BP-00000652-6).

**Mueller, R.P. 2002.** *Deepwater spawning of fall chinook salmon (Oncorhynchus tshawytscha) near Ives and Pierce Island of the Columbia River*. Project No. 1999-00304, 27 electronic pages (BPA Report DOE/BP-00000652-10).

**Mueller, R.P. 2003.** *Deepwater spawning of fall chinook salmon (Oncorhynchus tshawytscha) near Ives and Pierce Island of the Columbia River*. Project No. 1999-00301, 29 electronic pages (BPA Report DOE/BP-00000652-13).

**Platts, W.S., W.F. Megahan, and G.W. Minshall. 1983**. *Methods for evaluating stream, riparian, and biotic conditions.* Technical Report INT-138, U.S. Forest Service, Washington, D.C.

**Poston, T.M., R.W. Hanf, R.L. Dirkes, and L.F. Morasch (eds).** 2004. *Hanford Site Environmental Report for Calendar Year 2003*. PNNL-14687, .Pacific Northwest National Laboratory, Richland, Washington.

**U.S. Fish and Wildlife Service. 1999.** *Endangered and threatened wildlife and plants; listing of nine evolutionarily significant units of chinook salmon, chum salmon, sockeye salmon, and steelhead.* Federal Register 64:41835-41839.

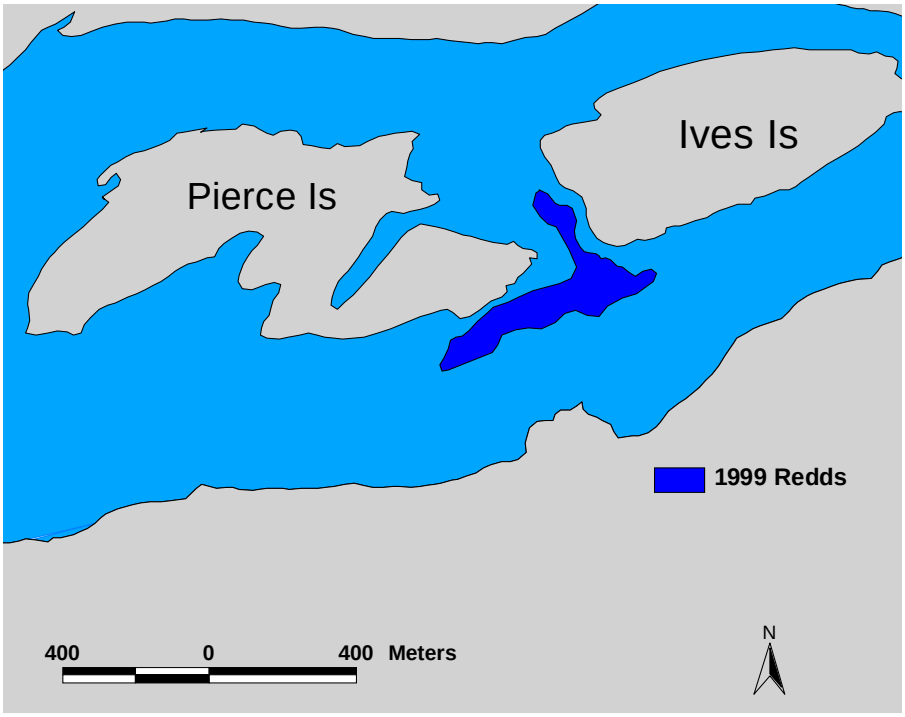
**Van der Naald, R. Clark, and B. Spellman. 2000-2001.** *Evaluation of fall chinook and chum salmon spawning below Bonneville, The Dalles, John Day, and McNary Dams*. Prepared by Oregon Department of Fish and Wildlife for Bonneville Power Administration, Contract No. 1999-00301, Project No. 1999-00301, 33 electronic pages (BPA Report DOE/BP-00004028-1).

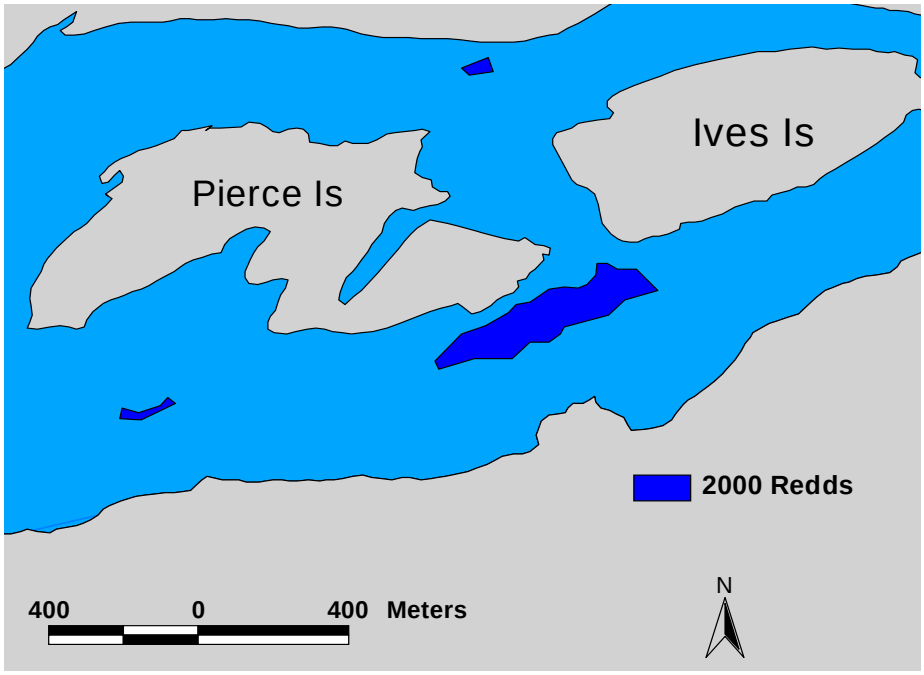
**Van der Naald, W., R. Clark, and B. Spellman. 2001-2002.** *Evaluation of fall chinook and chum salmon spawning below Bonneville, The Dalles, John Day and McNary Dams*, prepared by Oregon Department of Fish and Wildlife for Bonneville Power Administration, Project No. 1999-00301, 33 electronic pages (BPA Report DOE/BP-00004028-2).

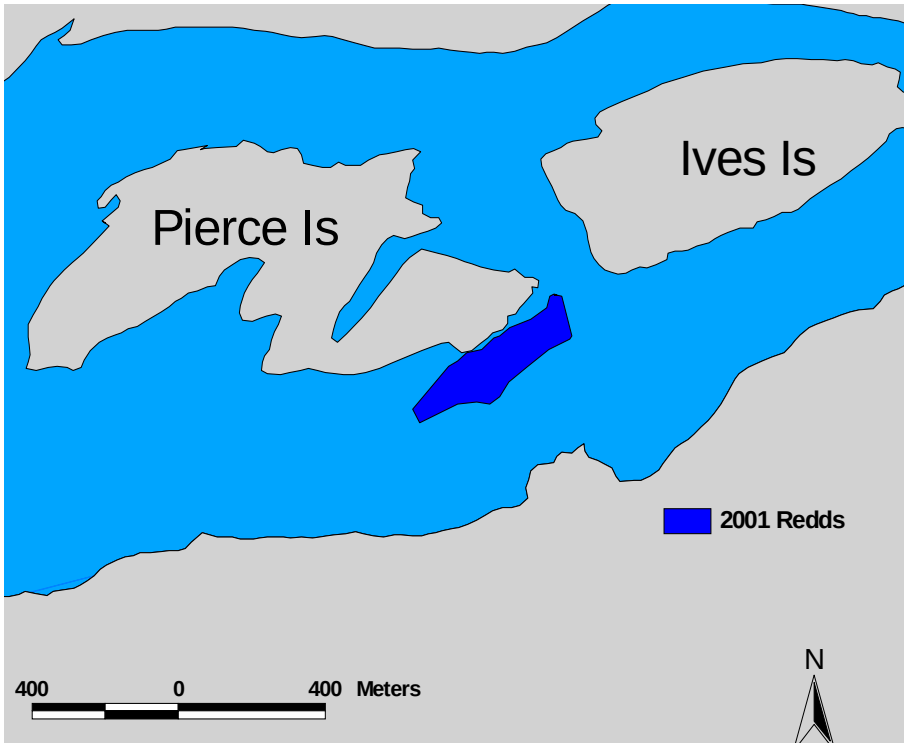
**Visser, R.H. 2000.** *Utilizing remotely sensed imagery and GIS to monitor and research salmon spawning: A case study of the Hanford Reach fall chinook (Oncorhynchus tshawytscha)*. PNNL-13177, Pacific Northwest National Laboratory, Richland, Washington.

# Appendix A

Maps Illustrating Fall Chinook Salmon Redd Spawning Areas, 1999 Through 2002

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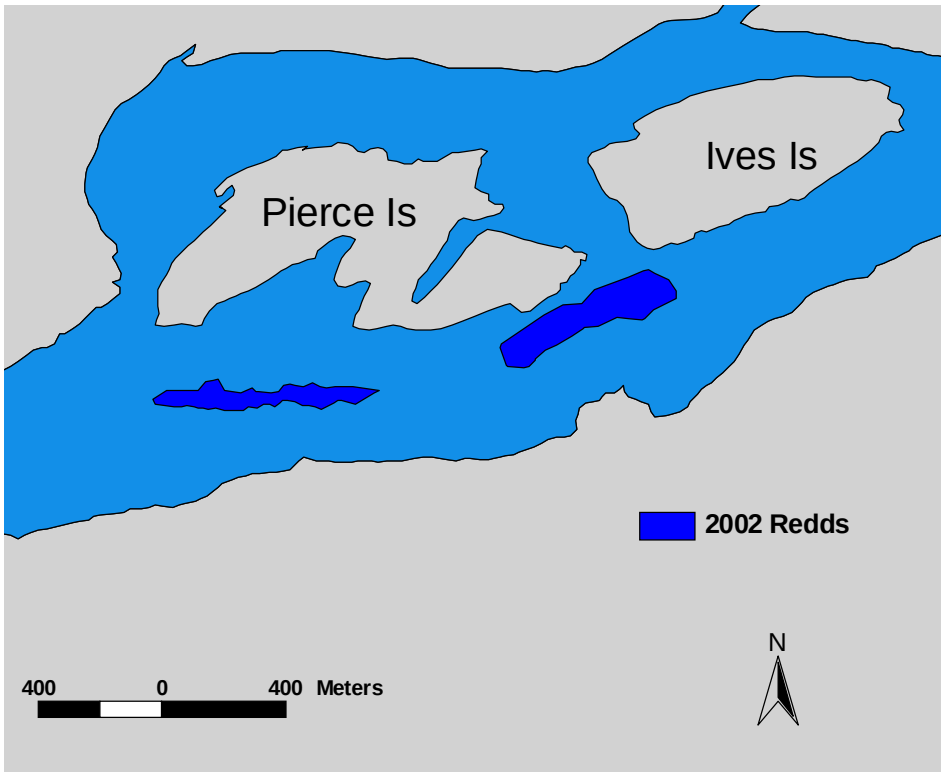
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