# APPENDIX G

## Wenatchee Sockeye and Summer Chinook Spawning Ground Surveys, 2006

**PUBLIC UTILITY DISTRICT NUMBER 1 OF CHELAN COUNTY**
**Fish and Wildlife Department**
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**February 10, 2007**

To: HCP Hatchery Committee

From: Chuck Peven

**Subject: 2006 Wenatchee River Basin Summer Chinook and Sockeye Salmon Spawning Ground Surveys**

# Introduction

The Chelan County Public Utility District (District) has conducted or funded others to conduct intensive spawning ground surveys of spring and summer/fall (late run)[1] Chinook salmon *Oncorhyncus tshawytscha* and sockeye salmon (*O. nerka*) in river basins of the Columbia River upstream of Rock Island Dam. Summer/fall Chinook spawn in the entire mainstem of the Wenatchee River, from the mouth to the lake (Figure 1; Table 1). Sockeye spawn in the White and Little Wenatchee river basins (Figure 2).

The spawning surveys are performed yearly to assist in evaluating the effectiveness of the District's hatchery program. The purpose of this document is to report the results of the 2006 Chinook and sockeye salmon spawning ground surveys in the Wenatchee River basin. Information included in this document describes abundance, distribution and timing of spawning activity.

## Study Area

The Wenatchee River originates from Lake Wenatchee and flows 54 miles south/southeast to its confluence with the Columbia River near the city of Wenatchee (Figures 1 and 2). The river drains an area approximately 1,301 square miles (United States Geological Survey (USGS) 2006). From its origin at the lake to river mile (RM) 22, it passes through heavily forested mountains. Below RM 22, the river enters a broad valley predominantly planted with fruit orchards. The mean annual flow at Monitor gage station is 3,255 $ft^3/s$ (1963-2004; USGS 2006), with a mean gradient ranging from 0.21-1.3% (Peven 1990). Primary tributaries of the Wenatchee River include the Little Wenatchee and White rivers, which flow into Lake Wenatchee, and Nason Creek, Chiwawa River, Icicle and Peshastin creeks (Figures 1 and 2).

[1] The majority of chinook that ascend the mid-Columbia River as adults after July spawn between October and November in the mainstem of the Columbia, Wenatchee, Methow, Similkameen and Okanogan rivers. These fish have been called "summer" and "fall" chinook based on their migration timing past the dams. Their life histories are identical (Mullan 1987), and should be termed "late-run" to separate them from earlier running "spring" chinook which have a different life history. For consistency with previous year's reports, only the earlier segment of the late-run (those that ascend Rock Island Dam between June 24 and September 1; "summers") will be focused on in this report.

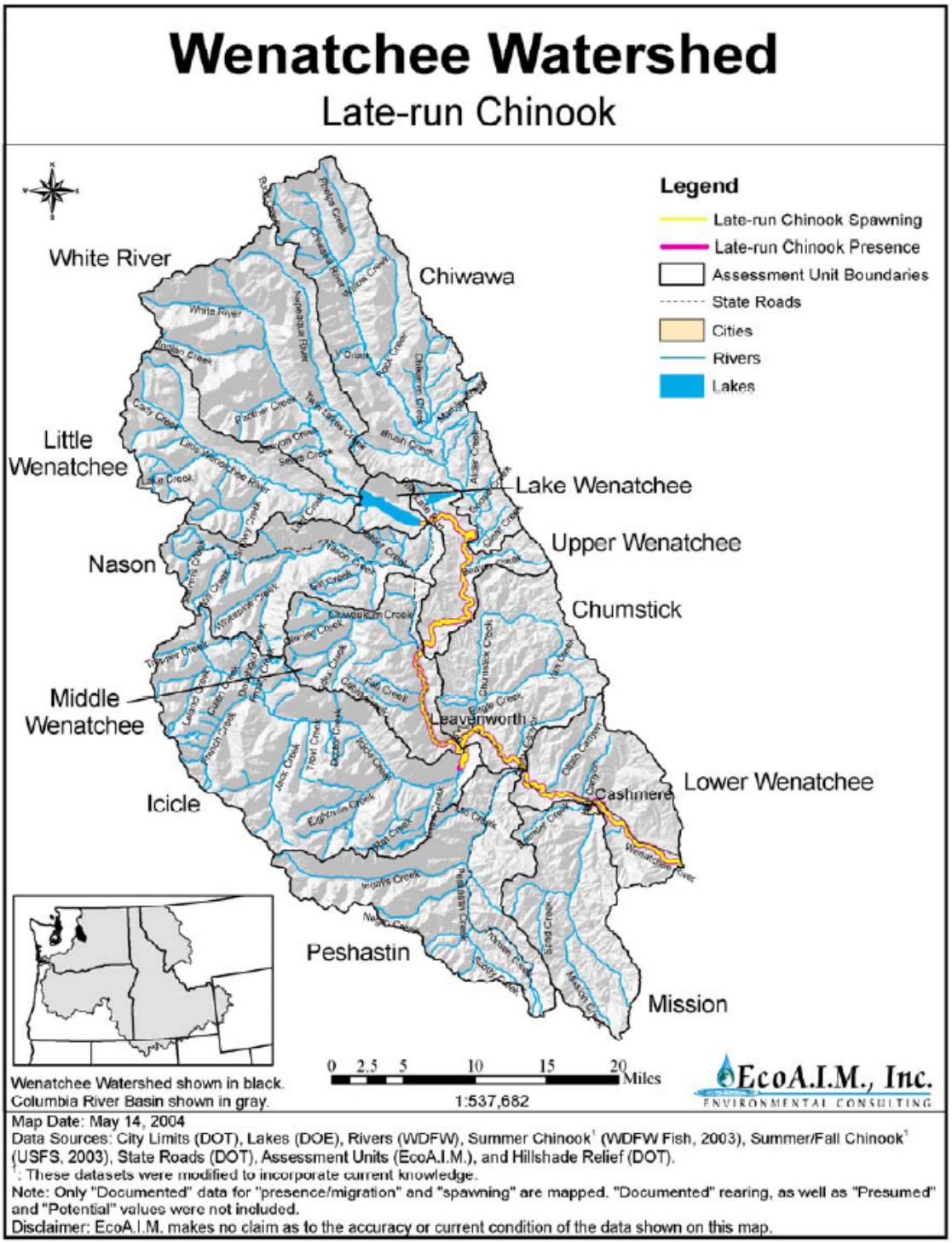


Figure 1. Map of the Wenatchee River Basin with spawning and migrational of late-run (summer/fall Chinook) areas highlighted (copied from the Wenatchee Subbasin Plan, NWPCC 2004).

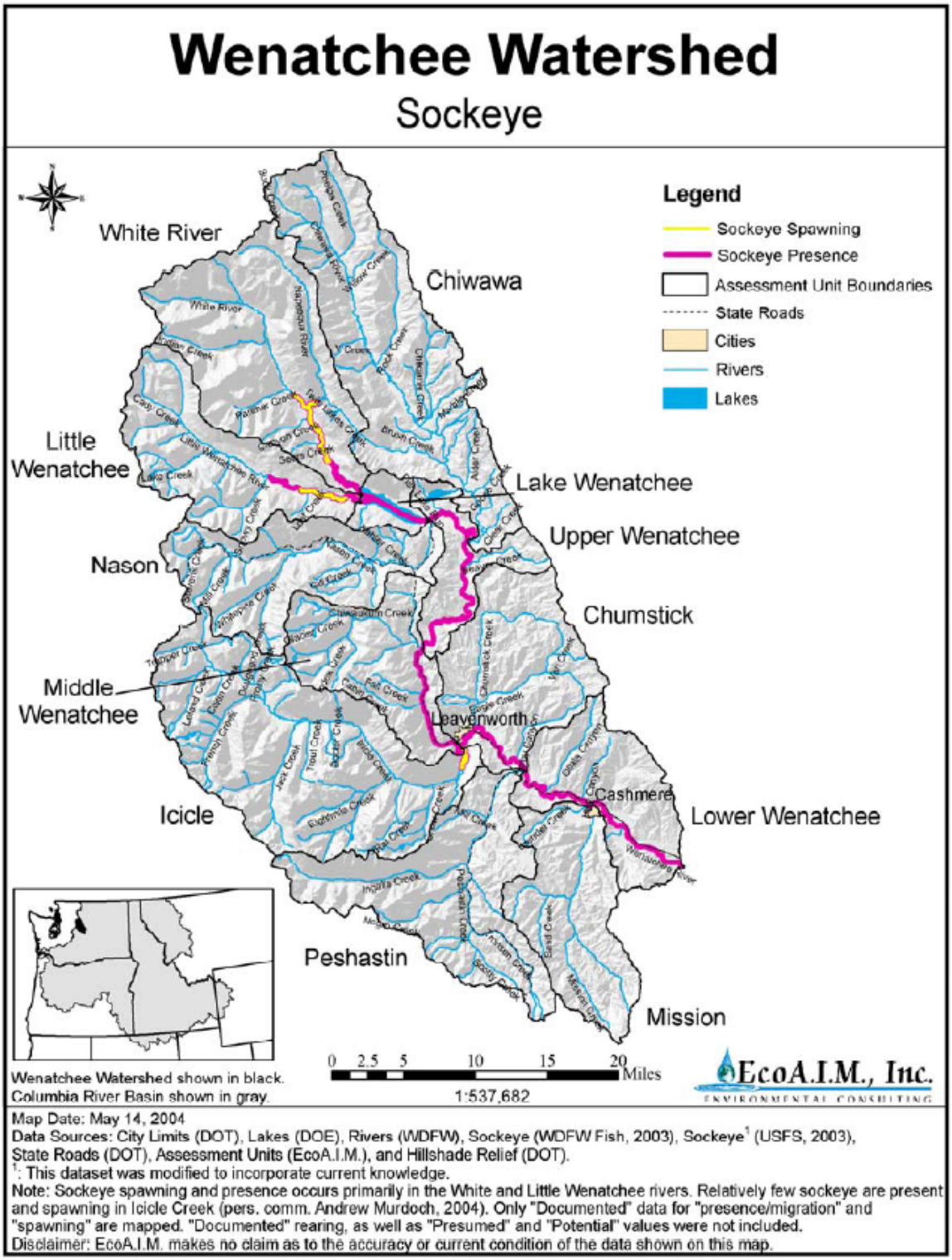


Figure 2. Map of the Wenatchee River Basin with spawning and migrational areas for sockeye highlighted (copied from the Wenatchee Subbasin Plan, NWPCC 2004).

# Methods

***Chinook Spawning Ground Surveys***

Chinook spawning ground surveys are conducted by foot, raft, or canoe. The most appropriate survey method is chosen for a given stream reach based on stream size, flow, and density of spawners. Because of the broad stream width and high spawner densities individual summer Chinook redds are not flagged. Each reach is surveyed approximately once per week.

In 2006, summer Chinook spawning ground surveys occurred from September 25 to November 3rd (surveys were cut short because of a large rain event that prevented further surveys).

***Table 1: Designated survey reaches for spawning ground areas on the Wenatchee, Little Wenatchee, White, and Nepeequa rivers for all species.***

| **Wenatchee River** | |
|---|---|
| **Survey Section** | **River Mile** |
| Mouth to Sleepy Hollow Bridge | 0 – 3.5 |
| Sleepy Hollow Bridge to Lower Cashmere Bridge | 3.5 – 9.5 |
| Lower Cashmere Bridge to Dryden Dam | 9.5 - 17.5 |
| Dryden Dam to Peshastin Bridge | 17.5 – 20.0 |
| Peshastin Bridge to Leavenworth Bridge | 20.0 – 23.9 |
| Leavenworth Bridge to Icicle Road Bridge | 23.9 – 26.4 |
| Icicle Road Bridge to Tumwater Dam | 26.4 – 30.9 |
| Tumwater Dam to Tumwater Bridge | 30.9 – 35.6 |
| Tumwater Bridge to Chiwawa River | 35.6 – 48.4 |
| Chiwawa River to Lake Wenatchee | 48.4 – 54.2 |
| **Little Wenatchee River** | |
| Mouth to Old Fish Weir | 0 – 2.7 |
| Old Fish Weir to Lost Creek | 2.7 – 5.2 |
| Lost Creek to Rainey Creek | 5.2 – 9.2 |
| Rainey Creek to End | 9.2 – End |
| **White River** | |
| Mouth to Sears Creek Bridge | 0 – 6.4 |
| Sears Creek Bridge to Napeequa River | 6.4 – 11.0 |
| Napeequa River to Grasshopper Meadows | 11.0 – 12.9 |
| Grasshopper Meadows to Falls | 12.9 – 14.3 |
| **Napeequa River** | |
| Mouth to End | 0 - End |

Peak and total redd count methodologies are used during the summer Chinook surveys (see Appendix F of Murdoch and Peven (2005) for more detail). A peak count is conducted by counting all visible redds (new and old) observed within a reach on each survey. The objective of the peak redd count methodology is to capture the apex of

spawning activity over an entire spawning season. This apex occurs at different times between reaches during the season, i.e. spawning begins sooner in the upstream reaches compared to the downstream reaches. The sum of all of the apex counts for the entire river is the peak redd count for the year. Peak counts provide an index of spawning and have been used historically (Appendix 1).

A total redd count is conducted by counting or mapping only new or recently constructed redds within an area. Each new redd is mapped on aerial photos and enumerated. The objective of the total redd count methodology is to capture 1) "early" redds that may fade over time due to siltation or algae growth, and 2) redds that become disfigured by superimposition (when new redds are constructed on top of previously existing redds).

Since it is not feasible to map all new redds within the entire river, an expansion is used to estimate total count for the entire Wenatchee River. To account for the different spawning substrate types in the main stem Wenatchee River, the river was delineated into six distinct reaches in consultation with WDFW (Table 2). Within each of these reaches, index areas have been identified as being representative areas of spawning activity. Peak counts are performed within each total reach, while mapping new redds only occurs within the index areas. An expansion is developed based on the ratio of mapped to peak counts for each reach (i.e., each reach has its own expansion factor), and the sum of the expanded counts is the estimate of the total redd counts. Additional details of how total redd counts are calculated is provided below.

a. Calculate an index expansion factor (index factor; *IF*) by dividing the number of visible redds in the index by the total number of redds in the index area.

$$IF = n_{visible} / n_{total}$$

b. Expand the non-index area redd counts by the proportion of visible redds in the index to estimate the total number of redds in the entire reach (reach total; *RT*).

$$RT = n_{non-index} / IF$$

c. Estimate the total number of redds (total redds; *TR*) by summing the reach totals.

$$TR = \sum RT$$

The total redd count methodology is believed to be a more accurate indication of total spawning than the peak redd count methodology, because the peak count methodology only accounts for visible redds each week during the survey season. For example, summer Chinook redds that were visible during the first week of spawning may not be visible during the third week; those redds would be missed in the third and subsequent

weeks' redd counts. Using the total count methodology, the redds in the first week would be mapped and accounted for in subsequent weeks, even though they may fade at some point during the future surveys.

***Table 2: Index (Mapping) Areas on the Wenatchee River.***

| Wenatchee River | | |
|---|---|---|
| **River Reach** | **Check Points (sections)** | **Mapping Index Area** |
| 1 | Mouth to Sleepy Hollow Bridge | Monitor Bridge to Lower Cashmere Bridge |
| | Sleepy Hollow Bridge to Lower Cashmere Bridge | |
| | Lower Cashmere Bridge to Dryden Dam | |
| 2 | Dryden Dam to Peshastin Bridge | Dryden Dam to Peshastin Bridge |
| | Peshastin Bridge to Leavenworth Bridge | |
| 3 | Leavenworth Bridge to Icicle Road Bridge | Icicle Mouth to Takeout |
| 4 | Icicle Road Bridge to Tumwater Dam | Swiftwater Campground to Tumwater Bridge |
| | Tumwater Dam to Tumwater Bridge | |
| 5 | Tumwater Bridge to Chiwawa River | Swing Pool to Railroad Tunnel |
| 6 | Chiwawa River to Lake Wenatchee | Swamp to Bridge |

***Sockeye Spawning Ground Surveys***

In 2006, we employed two different survey methods; total redd counts and area-under-the-curve (AUC). Sockeye spawning ground surveys began August 29 and ended October 24. Surveys were conducted by foot twice-weekly in known sockeye spawning areas (i.e. redd superimposition). Spawning areas in the Little Wenatchee, White, and Napeequa rivers (Table 1) were surveyed at least once per week. Both the Little Wenatchee and White rivers have blocking falls, and spawning is only known to occur within the first few miles of the Napeequa River.

*Total redd counts*

The crews conducted total redd counts. The same observers conducted the surveys to minimize observer bias. Redds were either flagged or mapped. Areas of high spawning density were divided into sections and each section had detailed maps drawn for completed redds/redd starts. Redd starts were identified by a circle; completed redds were identified with an X placed inside a circle. In areas which did not have mass spawning, redds were identified with survey flagging tied near each redd.

*Area-under-the-curve*

The AUC method is based on the number of live spawners counted. Using AUC, the number of fish observed in a survey is plotted against the day of the year and the number of fish-days is estimated using an algorithm. The number of fish spawning is then estimated by dividing the cumulative fish-days by the estimated mean number of days

that the average spawner is alive in the survey area (survey- or stream-life). This is then multiplied by a correction factor for fish visibility (observer efficiency; Hillborn et al. 1999).

Hillborn et al. (1999) outlined what they termed as the most commonly used form of AUC, *trapezoidal approximation*:

$$AUC = \sum_{i=2}^{n} (t_i - t_{i-1}) \frac{(x_i + x_{i-1})}{2}$$

where $t_i$ is the day of the year and $x_i$ is the number of salmon observed for the *i*th survey. Attempts are often made to initiate surveys prior to the presence of fish; however when the first or last survey is not zero, then the above algorithm is not valid and Hillborn et al. (1999) recommend using the "rules" that the Alaska Department of Fish and Game use:

$$AUC_{first} = \frac{x_i s}{2}$$

Where *s* is the survey life. Attempts should also be made until all salmon die, but when this is not possible, then the final survey should be calculated:

$$AUC_{last} = \frac{x_{last} s}{2}$$

Then total escapement (*E*) is estimated:

$$\hat{E} = \frac{AUC}{s} v$$

where v is a correction for observer efficiency. Hyatt et al. (2006) have not used an estimate of observer efficiency in their use of AUC for Okanogan sockeye because one has not been obtained. The hatchery effectiveness technical team (HETT) is investigating whether a method can be employed in future surveys that will allow an estimate of observer efficiency.

Perrin and Irvine (1990) reviewed literature and conducted surveys to determine stream life for five species of Pacific salmon. For sockeye, the mean stream-life was 13.2 days (range: 7-26.5). Hyatt et al. (2006) used a stream-life of 11 days because of the Okanogan sockeye's similarity to Early Stuart sockeye. We used 11 days also. The HETT is investigating whether or not there may be methods available to estimate this metric.

# Results

***Summer Chinook***

Peak Counts (non-index areas)

A peak redd count of 7,165 summer Chinook redds was estimated in 2006 based on ground surveys along the Wenatchee River (Table 3). Spawning activity began the last week of September and peaked during the second week of October.

Density of redds was greatest near the confluence of the Icicle and Wenatchee rivers (the "golf course" area). Upstream of Tumwater Dam to Plain was the next highest areas (Table 4).

Table 3. Summary of summer Chinook redd counts in the Wenatchee River, 2007.

| Survey Section | River Section | Peak Counts | Total Counts |
|---|---|---|---|
| Mouth to Sleepy Hollow Bridge | W-1 | 79 | 79 |
| Sleepy Hollow Bridge to Lower Cashmere Bridge | W-2 | 346 | 346 |
| Lower Cashmere Bridge to Dryden Dam | W-3 | 392 | 392 |
| Dryden Dam to Peshastin Bridge | W-4 | 152 | 155 |
| Peshastin Bridge to Leavenworth Bridge | W-5 | 157 | 604 |
| Leavenworth Bridge to Icicle Road Bridge | W-6 | 1,789 | 1,789 |
| Icicle Road Bridge to Tumwater Dam | W-7 | 535 | 1,029 |
| Tumwater Dam to Tumwater Bridge | W-8 | 577 | 814 |
| Tumwater Bridge to Chiwawa River | W-9 | 1,684 | 1,786 |
| Chiwawa River to Lake Wenatchee | W-10 | 1,454 | 1,834 |
| **Totals** | | **7,165** | **8,827** |

Total Counts

A total redd count of 8,827 summer Chinook redds was estimated in 2006 based on partially expanded ground counts (Table 3).[2] We were unable to expand all 10 reaches within the Wenatchee because final surveys (naïve) were not conducted in some reaches (primarily the lower reaches) because a freshet that rendered observation impossible.

Historical Summer Chinook Spawning Ground Survey Data

The historical summer Chinook survey estimates (1996-2006) for the Wenatchee River basin are presented in Appendix A. The estimated summer Chinook redd count for the 2006 season was the highest count on record (Figure 3).

[2] Note – the current protocol is to derive an index for expansion of six of the 10 sections on the mainstem Wenatchee River. We propose to index all 10 sections next year.

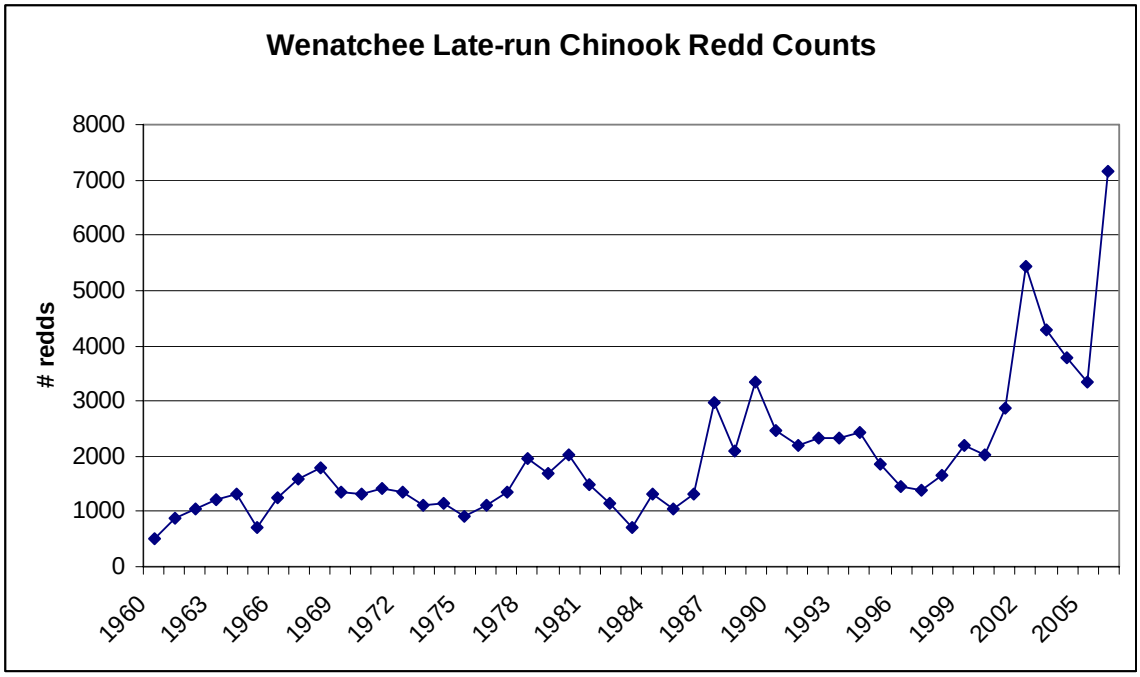


Figure 3. Historic summer/fall Chinook redd counts in the Wenatchee River Basin (see Appendix A for more information).

Table 4. Summary of summer chinook redds (from peak redd counts) in the mainstem Wenatchee River 2006.

| Section | Rivermile | No. of redds (ground) | Miles in Section | Redds per mile (ground) |
|---|---|---|---|---|
| Lake - Old Plain Bridge | 54.2 | 1,454 | 12.3 | 118.2 |
| Old Plain Bridge. - Tumwater Br. | 41.9 | 1,684 | 6.3 | 267.3 |
| Tumwater Br. - Tumwater Dam | 35.6 | 577 | 2.9 | 199.0 |
| Tumwater Dam - Icicle Rd. Br. | 30.9 | 535 | 6.3 | 84.9 |
| Icicle Rd. Br. - Leavenworth Br. | 26.4 | 1,789 | 2.5 | 715.6 |
| Leavenworth Br. - Peshastin Br. | 23.9 | 157 | 3.9 | 40.3 |
| Peshastin Br. - Dryden Dam | 20.0 | 152 | 2.5 | 60.8 |
| Dryden Dam - Lower Cashmere Br. | 17.5 | 392 | 8.0 | 49.0 |
| Lo. Cashmere Br. - Sleepy Hollow Br. | 9.5 | 346 | 6.0 | 57.7 |
| Sleepy Hollow Br. - Mouth | 3.5 | 79 | 3.5 | 22.6 |
| **Total:** | | **7,165** | **54.2** | **132.2** |

***Sockeye***

Redd and fish counts

Redd and fish counts were conducted for sockeye from August 29 through October 24. Peak spawning occurred in the White River basin (3,998) and Little Wenatchee (400) during the third-fourth week of September (Figure 4; Table 5).

During the spawning period, 2,747 sockeye redds were counted in the Wenatchee Basin. Most were observed in the White River basin (91% or 2,493 redds) (Table 5). The Little Wenatchee River contained 254 redds (9%).

Escapement

As previously discussed, two different methods were used to estimate sockeye spawning escapements. The first applied a fish/redd ratio to the estimated number of redds counted in each subbasin (i.e., escapement = fish/redd x redds). The second used the AUC method to estimate sockeye escapement. The latter relied on weekly counts of live sockeye and assumed a redd residence time of 11 days and an observer efficiency of 100%.

Using the fish/redd approach, the estimated total spawning escapement of sockeye in the Wenatchee Basin was 5,275 (Table 5). This was estimated using a fish/redd ratio of 1.92, which was based on counts of male and female sockeye sampled at Tumwater Dam. In contrast, the AUC approach estimated an escapement of 7,813 sockeye, which was about 1.5 times greater than the fish/redd approach (Table 5).

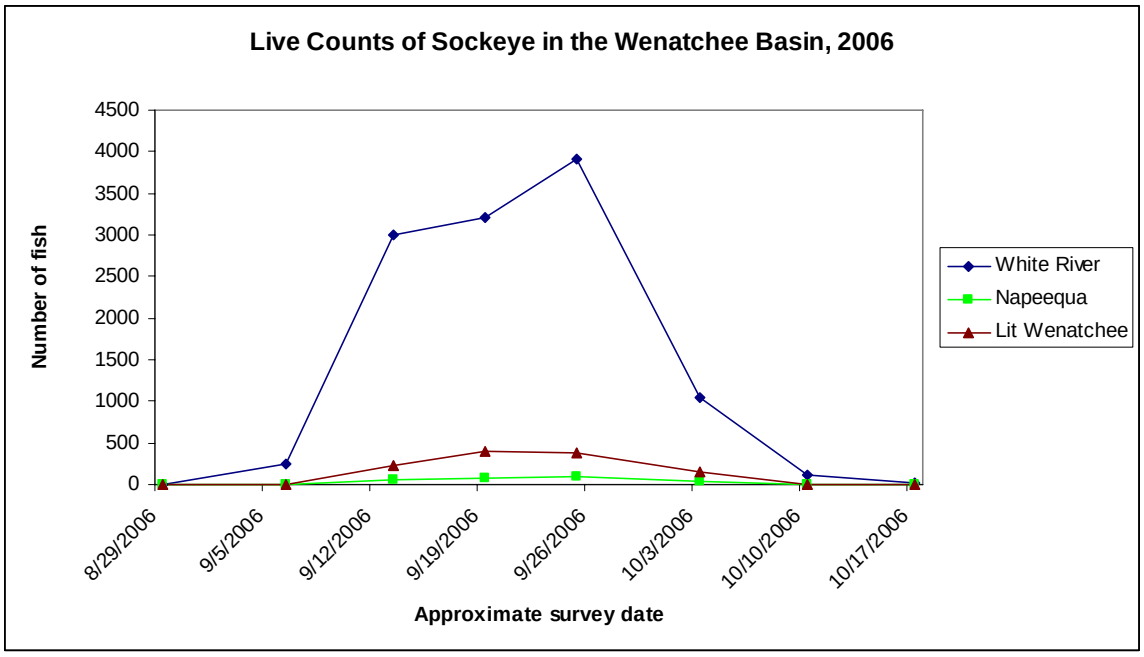


Figure 4. Live counts of sockeye salmon per survey in the Wenatchee River Basin, 2006.

Table 5**.** Number of redds and total spawning escapement estimates for sockeye salmon in the Wenatchee Basin, August through October, 2006.

| Sampling area | Total number of redds | Peak number of live fish | Escapement | |
|---|---|---|---|---|
| | | | Fish/Redd Method | AUC Method |
| Little Wenatchee | 254 | 400 | 488 | 710 |
| White R Basin | 2,493 | 3,998 | 4,787 | 7,103 |
| **Total** | **2,747** | **4,398** | **5,275** | **7,813** |

## Summary

District crews conducted extensive redd counts in the Wenatchee River basin in 2006 for summer Chinook and sockeye salmon. These surveys were conducted from late August to mid-November.

District crews counted 7,165 summer/fall Chinook redds (peak counts), and estimated that total redd counts were 8,827. Between late August and mid-October, 2,747 sockeye redds were counted, and escapement was estimated at 5,275 using fish per redd method or 7,813 using the AUC method.

## Recommendations

For estimating total summer/fall Chinook redd counts, all 10 mainstem Wenatchee River reaches should have index areas that are mapped so that can be expansions can be reach-specific.

Continue investigation into whether observer efficiency and spawner residency time can be estimated.

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# Appendix A.

Historic peak redd counts in the Wenatchee Basin for summer/fall Chinook salmon. Prior to 1995, all counts based on highest count of multiple agencies surveys, which were usually aerial counts from fixed-wing aircraft. Since 1995, counts are ground counts based on Chelan PUD surveys.

| Year | Highest Count | Year | Highest Count | Year | Highest Count |
|---|---|---|---|---|---|
| 1960 | 502 | 1970 | 1333 | 1980 | 2024 |
| 1961 | 872 | 1971 | 1419 | 1981 | 1469 |
| 1962 | 1035 | 1972 | 1364 | 1982 | 1140 |
| 1963 | 1223 | 1973 | 1119 | 1983 | 723 |
| 1964 | 1300 | 1974 | 1155 | 1984 | 1332 |
| 1965 | 706 | 1975 | 925 | 1985 | 1058 |
| 1966 | 1260 | 1976 | 1106 | 1986 | 1322 |
| 1967 | 1593 | 1977 | 1365 | 1987 | 2955 |
| 1968 | 1776 | 1978 | 1956 | 1988 | 2102 |
| 1969 | 1354 | 1979 | 1698 | 1989 | 3331 |
| 1990 | 2479 | 2000 | 2022 | | |
| 1991 | 2180 | 2001 | 2857 | | |
| 1992 | 2328 | 2002 | 5419 | | |
| 1993 | 2334 | 2003 | 4281 | | |
| 1994 | 2426 | 2004 | 3764 | | |
| 1995 | 1872 | 2005 | 3327 | | |
| 1996 | 1435 | 2006 | 7165 | | |
| 1997 | 1388 | | | | |
| 1998 | 1660 | | | | |
| 1999 | 2188 | | | | |